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EDITORIAL.

ITEMS AND NOVELTIES.

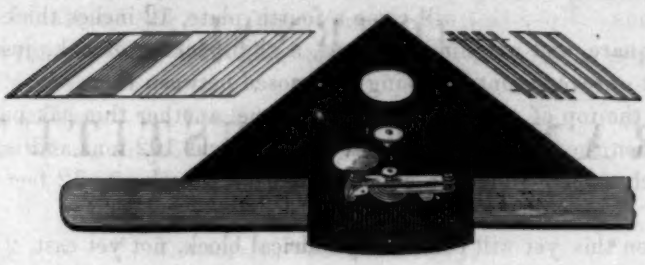
A Section Liner.—We have received from the makers of the instrument (Messrs. J. W. Queen & Co., Philadelphia), the accompanying engraving of a very simple and useful instrument for indicating sections of objects in mechanical and architectural drawings, for drawing screw threads, laying out the spaces of brick-work, and for use in all cases where narrow-spaced parallel lines are needed. The instrument was exhibited some months ago at a meeting of the Franklin Institute, by the inventor, Mr. Theodore Bergner, a member of the Institute. With it a person of moderate ability or practice can produce an effect of uniformity and neatness in sectional drawings almost or quite equal to the engine dividing of engravings.

The accompanying cut gives a perspective view of the instrument, together with a specimen of work executed with it. It consists of a ruler, covered on the under side with rubber cloth, a triangle with a clamping screw passing through near one of its edges, and a plate with the necessary arrangement for producing a movement over equal spaces.

The several parts are placed together as represented in the engraving, there being a little spring beneath the front edge of the top

plate, which presses against one edge of the ruler, while the triangle is clamped against the other edge.

The ruler may be placed upon the paper in any desired position,



the india-rubber cloth underneath keeping it there with perfect security, and it thus acts as a guide for the triangle, which can be moved along over equal steps by alternately pressing down the ivory button and letting it spring back. This movement is produced by the action of a little pawl upon the ruler, which is always to be kept quite sharp, so that it will take a quick and certain hold. The length of the steps taken, i. e., the distance between the lines drawn, is regulated by the screw above the spring, the distance moved over each time being greater as the spring is allowed to have more play. By changing the clamping screw on the triangle, any edge can be placed against the ruler.

The 35-ton Steam Hammer.—There is at present being constructed, for the use of the Royal Gun Factories in Woolwich Arsenal, perhaps the largest steam-hammer ever built. The building for containing this machine will be 150×100 feet.

The unusual size of the proposed machine necessitates a special arrangement for the bed plates. All of these are of a very massive and solid character, and consist in the first place of a hundred 12-inch square limber piles, arranged, at equal distances apart, in the form of a square, 30×30 feet. Around and between the piles, for a depth of 4 feet from the heads, is a bed of concrete. Upon the piles is laid a cast-iron plate, 11 inches thick and weighing 164 tons. This plate is in three parts, and upon it is placed a double layer of $1\frac{1}{2}$-inch oak baulks, the upper layer being placed at right angles to the lower one. Upon these oak baulks comes a second plate of cast-iron, 10 inches thick and weighing 121 tons. This plate is cast in two pieces and covers an area of 27×27 feet. Then comes a 2-ft. thickness of oak timber, consisting of baulks placed with the

grain vertical, or end on, the collection of baulks being held together by an iron strap 6 inches deep by 2 inches thick. These baulks carry a third cast-iron plate, 12 inches thick by 24 feet square and weighing 116 tons. Upon this will come a fourth plate, 12 inches thick by 22 feet square, and weighing 100 tons, a thin packing of oak, just sufficient to prevent contact, being interposed between them.

On the top of the last plate will come another thin oak packing, and then the round anvil block, which weighs 102 tons and is 3 feet 4½ inches deep, 15 feet in diameter at base, tapering to 12 feet at the top.

Upon this yet will come a cylindrical block, not yet cast, 2 feet 8 inches deep and 12 feet in diameter, which will weigh between 60 and 70 tons, and which will carry the movable anvil blocks, which will be of various sizes, to suit the work to be done.

These foundations will be seen, then, to include nearly 700 tons of cast-iron, so disposed as to present the utmost solidity, while at the same time retaining sufficient elasticity to prevent any detrimental consequences arising from the jar of the blows of the hammer, the falling weight of which will be 35 tons.

For the above details we are indebted to our contemporary "Engineering."

Building Stones and Fire.—In a paper upon the fire-withstanding qualities of various building stones, Dr. Adolph Ott, of New York, who has paid much attention to the subject, remarks that, as a class, the limestones are the worst building material of any of the natural stone, inasmuch as they calcine rapidly when exposed to a high temperature, a fact which was abundantly manifested in the memorable calamities which befel Boston and Chicago.

Of the limestones, it is further remarked, the varieties known as dolomite are the poorest, as the presence of magnesia lowers the temperature required to effect the calcination and disintegration of the stone.

Referring to the property of granite, gneiss, mica and other related primitive rocks to crack and explode when exposed to the radiant heat of a neighboring fire, a fact which has also recently received abundant verification, the writer refers the property to the expansive force of the water which all these rocks contain in their fissures.

Of all the natural stones, the author gives the highest place, as regards their heat-withstanding qualities, to the sandstones, which are composed almost entirely of quartz, a material which is only fusi-

ble at an enormously high temperature. The artificial stones, such as Portland and other cements, are also ranked very high for building purposes, their composition—essentially lime and alumina silicate—rendering them quite as capable of withstanding fire as the sandstones.

A Combined Heating and Ventilating Apparatus.—The accompanying engravings illustrate devices of this kind, designed and patented by Mr. Geo. R. Barker, a member of the Institute:

Fig. 1.

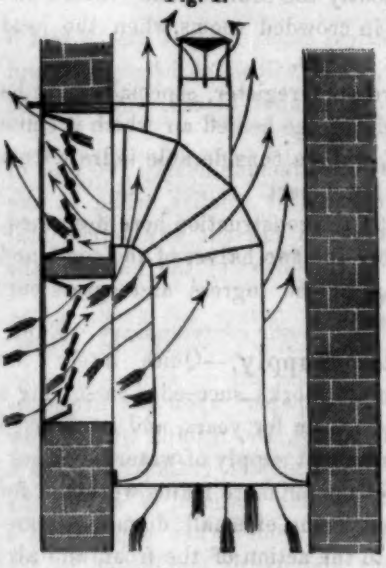
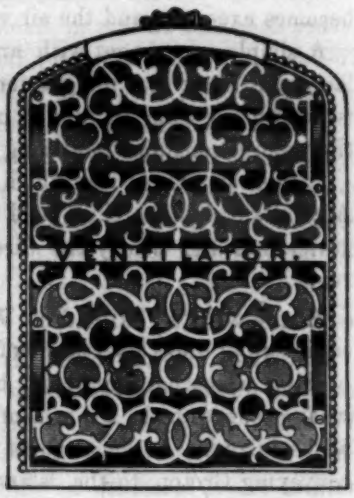


Fig. 2.



The apparatus is placed in a single flue, at the floor of the room to be warmed and ventilated.

The first figure shows a section of the plan. The flue, it will be observed, is supplied with a partition at some little distance below the register opening, through which the heat from the furnace below is to be delivered.

Upon this partition, and communicating directly with the heated air column, is placed a sheet-metal pipe, which terminates in the upper half of the register. Through this the heated air is poured into the room. The lower half of the register is designed for the ventilation; the design being thus to take advantage of the circulation which would be naturally established, and to draw off the somewhat cooled and vitiated air from below.

The second figure is a front view of the register face, showing the lateral division separating the heating and ventilating compartments from each other.

In the upper part of the hot-air pipe there is an adjustable valve secured, which can be operated by means of a handle projecting on the outside of the register-plate of the hot-air opening, whereby either a portion or the whole of the hot air rising in the said pipe can be discharged at any time into the vitiated air flue—the register of the hot-air pipe being either opened or closed accordingly—and thus increasing the warmth and consequently the draft of the vitiated air-flue; a result of great importance in crowded rooms when the heat becomes excessive and the air very impure.

A simple experiment with an ordinary register, especially if it be large, will show that the greater bulk of the heated air which it emits is thrown out from its upper part, while a considerable indraft from the room is constantly entering its lower part.

It was this observation which led to the construction here described. A candle or handkerchief held before the two halves of the combined device indicates clearly the direction of the ingress and egress currents.

Blackwell's Island's Water Supply.—Quite lately the engineers of the Department of Public Works succeeded in solving a problem which has apparently baffled them for years, and established what promises to be a means of permanent supply of water for Blackwell's Island. As long ago as 1850 one or more mains were laid for conveying Croton to the island, but being of small diameter, generally six inches, they were subject to the action of the frost, and also liable to be detached and carried away by vessels catching their anchors under them. In this way the sections were repeatedly detached and had to be renewed sometimes once or twice in a single season. During the winter the temperature of the water in the river very often sank to 30 degrees Fahrenheit, and the motion of the current also abstracted the heat from the pipe, which was of iron, to such an extent that if the water inside was not kept running it almost immediately froze, which it repeatedly did. To obviate this, at one time gutta percha pipes were substituted, but these, in addition to being more easily broken by the anchors of vessels, were continually being worn through by the current rubbing them against the rock bottom of the river. So repeatedly were the pipes, whether of iron or gutta percha, rendered useless in some way or other, that, although there were two

mains, one at Sixty-first street and another at Seventy-ninth (at one time there was one at Seventieth street), the island was continually left dependent upon the two weeks' supply in its reservoir, and sometimes water had to be carried over in boats. The main recently laid consisted of an iron pipe, six inches in diameter, encased in a box, formed of heavy timber, twenty-two inches square. The planks were firmly welded and riveted together, the intervening space being filled in with closely packed cement, and the whole forming a single continuous mass nearly 1300 feet in length. When lying along Sixty-second street, in process of formation, it extended nearly to Second avenue. The total weight was about 200 tons. The river at this point is 1140 feet wide and nearly 100 feet deep, while the current moves at least six miles an hour, so that the safe landing of this enormous mass was quite a triumph of engineering skill. The means used were a dredge-boat of 100 horse-power, worked along a wire cable one inch and a half in diameter, and two powerful tug-boats. Under the main, at intervals of every seventy-five feet, were launching ways, and human power was distributed all along the line. In case of the breaking of the cable, ropes were ready at hand to be used with the tugs alone. A successful start was made, and by ten o'clock nearly 100 yards of the mass was projected into the river. Then the strain on the cable proved so great that a wait was made for slack-tide, which was about four o'clock. From that time forward the work was rapidly pushed, and did not cease till the end of the main was securely rested on a stone abutment waiting to receive it on the island. Water was let in soon afterwards, but turned off as soon as it was perceived that the experiment was a success.

Chemistry of the Bessemer Process.—The conclusions reached by Kessler in regard to the theory of the Bessemer process may possess some interest to our metallurgical readers, since they differ somewhat from the views generally advocated.

The observer in question finds that in the Bessemer process of steel-making the entire amount of carbon present at first is relatively increased, owing to the more energetic oxidation of certain other substances in the iron in the earlier portions of the "blow," and that the carbon first begins to oxidize after the major portion of the silicon has disappeared.

Concerning phosphorus—the most obstinate impurity—Kessler declares that its amount is decreased during the middle portion of the

process, but that its proportion is relatively increased both at the commencement of the "blow," owing to the more energetic oxidation of the other impurities, and towards the end of the operation, when it is, to some extent at least, taken up again from the slag. Sulphur decreases rapidly at first, but increases again in the middle stage, up to the addition of the spiegel-eisen, for the reason that a portion of it, which in the first stage went into the slag, is afterwards taken up again by the iron. When the spiegel-eisen is added and the "blow" recommenced, the sulphur again diminishes, and the suggestion is made that if it were possible to remove the first slag, which contains much of the sulphurous impurities, it would be possible to use brands of iron which are known to contain sulphur for making Bessemer steel.

Rubber Tubes and Coal-Gas.—It has lately been observed that the illuminating power of coal-gas was considerably affected by the passage of the gas through rubber tubing before combustion. For this observation we are indebted to M. Zulkowsky, who has made a series of photometric experiments to determine the amount of this deterioration.

The following series of experiments are tabulated by the author:

Illuminating Power of Gas.

	Estimated direct.	After passing through rubber tubing.	Estimated direct.	After passing through rubber tubing.	Estimated direct.
1st Series,	13·2	10·7	12·9		
2d Series,	12·2	9·2	12·1		
3d Series,		7·8	11·2	7·5	11·3
4th Series,		9·8	11·6	9·9	12·

The diminution in the intensity of the light was so marked after the gas had been passed through rubber tubing of 4½ yards in length that it could be perceived without the help of a photometer; so perceptible, indeed, that the author deemed it to prove beyond question the fact that a positive absorption of some of the light-giving constituents of the gas takes place under these circumstances.

To ascertain which of the ingredients of the gas were thus effected the author carefully dried and weighed several pieces of black tubing and passed a stream of carefully dried gas through them for 62 hours, and found that at the end of that time the tubing had increased in weight 8·64 per cent. The tubing was subsequently placed beneath

the air-pump with sulphuric acid, when the gaseous ingredients were again evolved, the sulphuric acid indicating by its blackening that it had absorbed at least some of that which had thus been liberated from the tubing.

Further observation proved that about 1·1 per cent. of the total volume of the gas was absorbed by the tubing, and the author holds it to be proven that only the heavy hydro-carbons and vapor ingredients of the gas are so absorbed.

In future investigation with coal-gas, the behavior of rubber tubing in this respect must be carefully taken into account.

More Tin Discoveries.—The technical journals have of late years contained every now and then accounts of wonderful tin discoveries in our Western country, all of which however shortly proved either to be entirely unfounded or greatly exaggerated. The last statement of this kind comes to us in the form of the declaration that tin deposits of great richness have been discovered on the north shore of Lake Superior. These discoveries seem to possess the quality of genuineness, inasmuch as their reality has been vouched for by several excellent witnesses. The region in which the deposits have been found is situated in the Province of Ontario, about midway between the Sault Ste. Marie Canal and Thunder Bay. A number of explorations, it is said, were conducted in this wild and uninhabited region after the first announcement of the find of tin, and with the result of finding quite a number of veins of the ore.

As regards the abundance of the ore, or the precise geological character of the locality, no precise data are given. The extent of the region, as far as explored, is stated to be some twelve miles in a southeasterly direction along the lake shore.

The ores, which are said to have been analyzed by Drs. Torrey and Jennings and Prof. Williams, are described by those gentlemen as quite rich and remarkably free from injurious impurities.

The account of these discoveries bears such an aspect of genuineness that, unless great exaggeration has been perpetrated by the local explorers, the region will soon attract the attention of capitalists.

During the coming summer the localities will probably be explored by competent observers, when the true extent and value of the reputed discoveries will be brought to light. Should the first accounts prove in no way exaggerated, the fears of those who are troubled concerning the probable scarcity in the supply of this invaluable metal, in

view of the great draws upon the deposits of Cornwall and Banca, may be quieted, especially since to the new region, then, we may safely add that of Queensland, an account of which was published in one of the late issues of the "Journal."

Glycerin as a Solvent.—M. Klever has published a lengthy table of the solubility of various substances in glycerin, the following abstract of which may be of value to some readers of the "Journal." From his published observations it appears that one hundred parts, by weight, of glycerin dissolve, at ordinary temperatures:

Parts by Weight.	Substance.	Parts by Weight.	Substance.
20	Arsenious Acid.	0·20	Phosphorus.
20	Arsenic Acid.	20	Plumbic Acetate.
10	Benzoic Acid.	50	Potassium Arsenate.
10	Boric Acid.	3·50	" Chlorate.
15	Oxalic Acid.	25	" Bromide.
50	Tannic Acid.	32	" Cyanide.
40	Alums.	40	" Iodide.
20	Ammonium Carbonate.	8	Acid Sodium Carbonate.
20	" Chloride.	60	Borax.
5·50	Tartar Emetic.	98	Sodium Carbonate.
10	Barium Chloride.	20	" Chlorate.
30	Cupric Sulphate.	0·10	Sulphur.
7·50	Mercuric Chloride.	50	Zinc Chloride.
27	" Cyanide.	35	Zinc Sulphate.
1·9	Iodine.	50	Urea.

Parts by Weight.	Substance.
0·45	Morphine.
0·50	Quinine.
0·25	Strychnine.

Portable Ink.—From the "Journal of the Society of Arts" we learn that Prof. Bœttger has suggested an idea that may prove of service to exploring parties and others. White blotting-paper is saturated with anilin black, and several sheets are pasted together to form a thin pad. When wanted for use, a small piece is torn off and covered with a little water. The black liquid which dissolves out is a good writing-ink. A square inch of the paper will be found to perform considerable service, and, as water is always available, the ink is readily made.

Quantitative Spectroscopic Analysis.—The especial merit of the spectroscope has heretofore been regarded to be the determination of the presence of certain elements in a luminous body, when there in such minute traces as to altogether defy detection by other known methods of analysis. The idea of extending the indications of this method of analysis to the estimation of quantitative values has often been suggested, but the difficulties to be overcome are very great.

Quite recently the subject has received considerable attention in learned circles, in consequence of a communication to the French Academy by M. Janssen, the eminent spectroscopist, who has pointed out very clearly, in a memoir to that society, the principles upon which such an application of the spectroscope might be based.

Mr. Janssen indicates two independent methods of procedure in such investigations, which may be employed simultaneously, and so serve as a species of control upon results obtained.

One of these methods is to measure the intensity of the bright lines afforded by a substance in the spectrum; the other is the measurement of the time required for the complete volatilization of a substance in the flame.

It is said that an apparatus constructed to take advantage of the first-named method has been successfully employed to determine the quantity of certain elements in the ashes of plants.

Should further experiment verify the expectation here expressed, the practical value of the spectroscope, which has already achieved wonders, will be greatly enhanced.

The East River Bridge.—From private sources we learn that work upon the bridge is progressing rapidly. The first anchor-plate was cast, two weeks since, very successfully. Anchorage excavation will be completed in about two weeks. The first set of anchor bars, making at Phœnixville, are about ready for testing. Masonry gangs all at work on piers.

The Signal Service Bureau.—It is stated that the "bureau" is about to extend its already elaborate system of weather prophecies, so that the valuable and exact information which is now daily distributed about the country through the agency of the press, may be made accessible to those who are not so fortunately located as to be able to avail themselves of morning and evening papers.

To effect this extension of its usefulness, the "bureau" proposes

to avail itself of the rural post-offices as mediums for the distribution of weather intelligence. The territory east of the Mississippi has been divided into districts of about two hundred miles in extent in every direction, each having near its centre a telegraph office, to which the weather intelligence will be each day telegraphed from Washington. Immediately on receipt of this intelligence, copies of the same will be sent to all the post-offices within the district which can be reached by post as early as 6 o'clock P.M. These weather maps will then be posted up on bulletin-boards, and may be consulted by the farmers and others interested, who may thus be guided in their business affairs. The arrangement here proposed will doubtless contribute greatly to the efficiency of the "bureau."

Self-Lighting Signal Lantern.—Some experiments with the Holmes lamp have recently been published. This lamp depends for its efficiency upon the fact that the phosphuret of calcium, in contact with water, develops spontaneously combustible phosphuretted hydrogen gas. The experiments in question, which are stated to have turned out very satisfactorily, are as follows: A long tin tube, firmly closed, in which was contained 900 grains of the phosphuret of calcium, was kept afloat upon the water by being fastened to a piece of board. Before putting it in the water, the bottom of the tube was perforated to allow the water to enter, and the upper point cut off, so that on the entrance of the water the self-lighting phosphuretted hydrogen gas was developed.

A flame four or six inches broad and twenty-four inches high, lighted up the steamboat and pilot boat, which had gone out four miles on the sea, with a party to witness the experiments, so brilliantly that the vessels and the men upon them are stated to have been distinctly visible from the lighthouse at that distance.

The Planet between Mercury and the Sun.—The existence of an intra-mercurial planet has been frequently argued for upon astronomical grounds, though an objective proof of its presence has as yet not been forthcoming. Mr. Cowie, however, has lately telegraphed from Shanghai an account of a recent observation in which he assumes that a black spot seen on the sun's disk at 9 A. M., on March 24th, marked in reality the transit of the supposed planet. It must, however, be added that both the observation and the inference drawn therefrom need corroboration.

* Boston Journ. of Chem., April, 1873.

The Oxyhydrogen Light.—The concluding portion of M. Blanc's report upon the practical application of the light of M. Tessié du Mothay in Paris, contains the following interesting resumé:

The oxygen gas supplied for the purpose by the company, though never containing less than 13 to 14 per cent. of nitrogen, is believed to be as pure as can be expected when manufactured on so large a scale and for such a purpose. Sufficient time, it is stated, had not elapsed to show conclusively whether the manganate process of obtaining oxygen was as continuous as was claimed. With regard to the price of the oxygen, the same uncertainty exists in the mind of the critic. The light, the report continues, would, in its application to the public streets, encounter too many disturbing causes to render it reliable. For private purposes, however, the objections are not so great, as a carburizer and regulator can be more readily applied than to the street lamps.

For private purposes the oxyhydrogen light will require to each house special burners, a double set of pipes, two meters, two regulators, and a well-appointed carburizer, arrangements requiring an outlay of money and an amount of trouble too great to be deemed desirable.

The assertion that, with oxygen, the combustion is complete is incorrect. For complete combustion more oxygen than usual is required, and to obtain it much of the illuminating power of the gas is lost. The experiment in the boulevards have shown that for the illumination of streets the oxyhdrogen light is not economical, though, in a hygienic point of view, it may be far superior to the present modes of illumination.

Electrical Conductivity Affected by Light.—A most curious experiment, involving an alteration in the electrical conductivity of the element selenium, an element of very high resistance, has recently been published by Mr. Willoughby Smith. Mr. Smith took several bars of this substance of from 5 to 10 c. m. in length, and 1 to 1½ mm. in diameter. Each bar was hermetically sealed in a glass tube, and had a platinum wire at each end for the purpose of connection. It was found that the resistance altered materially, according to the intensity of the light to which the element was subjected. When the bars were fixed in a box with a sealed cover, so as to exclude all light, their resistance was at a maximum, and remained very constant; but immediately the cover was removed, the conductivity increased

from 15 to 100 per cent., according to the intensity of the light falling upon the box. The mere interception of the light, by passing the hand before an ordinary gas burner placed several feet from the bar, increased the resistance 15 to 20 per cent. When the light was intercepted by glass of various colors the resistance varied according to the amount of light passed through.

To insure that temperature had nothing to do with the results obtained, one of the bars was placed in a trough of water so that there should be about an inch of liquid for the light to pass through. The results under these conditions were the same. And again, when a strong light, from the ignition of a narrow band of magnesium, was held about 9 inches above the sealed tube, the resistance immediately fell more than two-thirds, returning to its normal condition, immediately the light was extinguished.

Asbestos.—The attempt which has recently been made, with some prospect of ultimate success, of incorporating asbestos into textile fabrics, by mixing the fibres of this substance with the cotton or wool during the weaving process, has attracted some attention to the localities where suitable deposits are known to exist. The material is by no means rare, since it is most generally present in greater or less quantity in regions where the so-called primitive formations are found. But while its employment, for several fire proofing compositions, tolerably well known to the manufacturing public, does not demand an article of unusually fine character, it appears that for its incorporation into textile fabrics only those qualities with the finest and longest fibres are suitable.

There are extensive deposits of this material within the limits of the United States; that found in the eastern slope of the Green Mountains and in the Adirondack region being of the best quality thus far discovered, for fineness and tensile strength. Recent discoveries, however, in North Carolina, may, when better known, carry the attention of those interested in the material to that region—it being asserted that deposits of unequalled quality exist in that State.

The fibre of the New York and Vermont asbestos varies in length from two to forty inches, and the material resembles unbleached flax when found near the surface, but when obtained from greater depths it is pure white and very flexible. In Europe, the material is found in considerable quantities in the Tyrol, in Hungary, Corsica and Wales.

The industrial applications of asbestos are steadily growing, and it bids fair to become, for certain purposes where its fire-withstanding qualities and its considerable tensile strength are prominently involved, an indispensible article, on which account the discovery of deposits of suitable quality may be regarded as of importance.

Ammonia for Mercury Vapors.—The fact that workmen exposed to the vapors of mercury for any considerable time seriously imperilled their health has long been well known, and various suggestions have, from time to time, been made to neutralize this danger in the industries largely employing this substance.

The last suggestion, which was made to the French Academy, consists in the free use of ammonia, which, it is stated, has been employed with success for several years by M. Meyer, in the mirror factory at Chauny. During the time that mercury has been employed, that is since 1858, no workman has been attacked by the mercury, while those men who were subject to the attacks of the disease have since suffered more rarely and less severely. The ammonia, it is recommended, should be thrown around the shops in the evening rather than in the morning.

FRACTURE OF CAST-IRON PIER CYLINDERS.

By John C. Trautwine, Civ. Eng.

It is not, perhaps, generally known to the profession that cast-iron cylinders, composed of sections bolted together through inside horizontal flanges and filled with concrete, as is usual when employing them for bridge piers, &c., have, in several instances, in the United States, cracked or split asunder, entirely around their circumference, under the influence of severe cold weather. The reason of this, I presume, is that the outer and more exposed cylinder tends to contract to a greater degree than the inside and more sheltered concrete, and that the hold which the inside flanges have upon the solidified concrete in which they are imbedded prevents the contraction from taking place without rupture of the cylinder. Unless suitable means be applied to prevent this, the efficiency of such cylinders may be much impaired. It has been suggested that an inside lining of vertical wooden staves, projecting inwards as far as the flanges do, will be an effective remedy. Other methods will no doubt present themselves. My object is merely to give greater publicity to an important fact.

NOTE ON THE PRODUCTION OF AMMONIA IN NITRIC ACID BATTERIES.

By W. Levison.

I first noticed the production of ammonia in a nitric acid battery while using a simple combination of the kind in the month of January, 1869, and on the 23d of that month I showed the phenomenon to Mr. Charles Pearce, at Cambridge. It was, however, observed under circumstances that led to its being for a long time considered due to a merely local action of the dissolving zinc upon nitric acid which had diffused through the porous cup, but recent experiments show, to my mind, that the ammonia produced in nitric acid batteries results from a reaction between the electrolytically liberated hydrogen and the nitrogen of the nitric acid in the inner cup.

As no discussion of the theory of the battery, to the best of my knowledge, takes cognizance of this reaction, I thought it might be new and worthy of attention. I must, however, confine this note to a mere statement of the fact.

January 14th, 1873. I put up two small Grove cells, constructed of zinc and platinum. The inner cups were filled with a mixture of

Saturated solution of potassic bichromate,	5	parts,
Commercial oil of vitriol,	2½	"
Nitric acid, C. P.,	1	"

The zincs, newly amalgamated, were put in dilute sulphuric acid. Distilled water only was used. One cup was set in operation, the other left. After 24 hours the liquids in these two batteries were examined for ammonia; the cup set in operation being called Battery A, the other Battery B. In testing the liquids from inner and outer cells of both batteries, ten cubic centimeters of each were separately concentrated to about one-fifth, treated with an excess of caustic soda and the platinum dish covered with a watch-glass having a piece of red litmus paper adherent to its under side.

Battery A. Liquid from inner cup. Paper immediately turned blue. Odor of ammonia strongly perceptible.

Battery A. Liquid from outer cell. Paper became blue in a short time. Odor of ammonia very faint. Only a trace present.

Battery B. Liquid from inner cup. Paper faintly changed in ten minutes. No odor of ammonia perceptible.

Battery B. Liquid from outside cup. Same result precisely.

Local action does not produce ammonia in important quantity.

January 26th, 1873. Set up a single cell, Grove form, with dilute sulphuric acid in outside cup, and a mixture of equal parts of saturated solution of potassic nitrate and Kalbfleisch's commercial oil of vitriol in inside cup. Proved in advance each liquid to be free from ammonia.

After 24 hours tested both liquids for ammonia. That from inner cup contained great quantities, but that from outer cup gave no evidence of containing ammonia.

February 1st, 1873. Set up a single cell grove with nitric and dilute sulphuric acid. Immediately after setting up, and before closing circuit, tested both liquids for ammonia. The nitric acid gave no trace of the sulphuric acid; gave a faint ammonia reaction, and yielded a trace of nitric acid, which probably got into it by diffusion through the porous cup. Ten minutes after putting battery in operation, ammonia in large quantity was found in inner cell.

The conversion of nitric acid into ammonia must be taken into consideration in preparing the nitro-chromic battery fluid, as proposed by me in the "Journal of the Franklin Institute," vol. 59, page 376, inasmuch as sufficient nitric acid must be used in excess of the quantity converted into ammonia during the time which elapses before the last molecule of chromic acid is reduced to chromic oxide.

Editorial Correspondence.

QUEBEC, *March 25th*, 1873.

Editor of Journal of Franklin Institute:

DEAR SIR,—I notice in this month's issue of your journal an account of an improved method of bending glass tubes for laboratory purposes.

I have long used a plan which, though probably adopted by many, I have not seen recommended. Instead of heating the tube in the flame of a Bunsen burner, I do so in the luminous flame of an ordinary fish-tail or bat's-wing burner, placing the tube across the flame when I want a sharp bend, but lengthways in the flame when I wish it to be gradual. Of course the tube is blackened, but the carbon can be readily wiped off with a dry cloth when the tube is cool. The diameter of the tube is much less likely to be contracted than when the ordinary method is employed.

Yours, J. DOUGLAS, JR.

Civil and Mechanical Engineering.

GAUGING OF RIVERS.

By Bvt. Brig. Gen. Henry L. Abbot, Major of Engineers.

The report upon the Physics and Hydraulics of the Mississippi river was completed during all the hurry and confusion attendant upon the commencement of civil war. Moreover, the scope of the work confined it strictly to the solution of the problems of protection for the low lands of the Mississippi against river floods, and of increased depth at the mouths. For these reasons the discoveries in the laws governing flowing water were merely announced incidentally, in order to establish the exactness of the solutions of problems which presented themselves in the prosecution of the work. As a practical treatise setting forth these discoveries its arrangement is therefore defective; and from the terseness of the language in which the principles are laid down, engineers have fallen into errors in applying them. Cautions once given were not repeated, but were supposed to be borne in mind and observed wherever applicable.

The chapters relating to the laws of flowing water have been translated into French and German, and extensively reviewed in this country and in Europe. The newly discovered laws and formulæ are now employed upon numerous river improvements in charge of officers of the Corps of Engineers. An important work upon hydraulics by MM. Darcy and Bazin, of the Corps des Ponts et Chaussées, published in 1865, has by new experiments and discoveries furnished means of testing and extending the laws laid down in the Hydraulics of the Mississippi. A still later work, published in 1867 by M. Heinr. Grebenau, has furnished additional and valuable data.

For these reasons, I propose to invite attention to such points in the report upon the Mississippi as, having been misapprehended, seem to require more full development; to define precisely the method of applying the new discoveries to the practical gauging of rivers; and, lastly, to test the new formulæ for discharge by all the fresh data furnished in the works of MM. Darcy and Bazin, and M. Grebenau.

Cautions Relating to the Use of River Formulæ.—The subject upon which misapprehensions have been most frequent, is the slope of natural streams. From misunderstanding this matter, the formulæ have

been erroneously applied in two ways—one of which makes them appear to give too large and the other too small mean velocities. A few words will make this subject clear, and define the limits within which it was contemplated that the application of the formulæ should be restricted.

In flowing between two points, A and B, most rivers encounter three distinct resistances to motion, in overcoming which they expend the power due to the fall in water surface between the two points. The first of these resistances is that arising from the adhesion of the water to its bed, and from the cohesion of the different particles to each other; the second resistance is that arising from inequalities of cross section, which give rise to disturbances, eddies and loss of living force; the third resistance is that due to bends, which act in a manner analogous to dams—checking the flow of the water and causing it to rise until it attains sufficient head to regain the lost velocity. The fall in water surface between A and B, which measures the power to overcome these three resistances, may, therefore, be considered to be divided into three parts, each of which overcomes one of the resistances.

Hence, if it were possible to obtain a complete mathematical expression for the flow of the river, it must comprise three formulæ based upon this triple division of the head. Unfortunately this division is impracticable for rivers, for the reason that the inequalities in cross section occasioning the second resistance cannot be determined with sufficient precision. This fact renders inapplicable to rivers the formulæ for "permanent motion" upon which many beautiful theoretical investigations have been made.

We are thus compelled to represent these three resistances by two formulæ. It would, perhaps, be possible to do this in the way which has been vainly attempted heretofore by hydraulic engineers—i. e. to frame one formula based upon the supposition of perfect uniformity of motion in a straight line for the distance between the points A and B—provided we should add a second formula which should measure the effect of the sum of the other two resistances. In other words, a formula with constants deduced from experiments upon smooth artificial canals, would be combined with one deduced to represent the total head consumed in rivers in overcoming the resistances due to variations in section and bends. This plan was not adopted in the investigations upon the Mississippi, as it was believed that better results would be obtained by dividing the effect of the

second resistance between the constants of the formulæ representing the other two. In straight portions of rivers with ordinary slopes, the disturbances arising from variation in section do not materially differ; and a certain kind of approximate uniformity of motion exists, which constants properly deduced from observations on rivers may represent as accurately as others do the perfectly uniform motion of smooth canals and troughs. The principal effect of the second resistance is confined to the vicinity of bends, where the changes in cross sections are the most violent; and this resistance is, therefore, chiefly taken into account by the bend formula; but it must be carefully borne in mind that the portion thus accounted for does *not include the whole*. There is a distinct part of this second resistance which necessarily affects the constants of any formula based upon the supposition of uniform motion and derived from observations upon natural channels. Such formulæ should, therefore, never be applied to water flowing in smooth artificial channels, where perfect uniformity of motion is obtained. This mistaken use has in a few instances been made of our formulæ.

A second and worse error has arisen from using in the formula for the first resistance, the whole fall in water surface between the points A and B, without first subtracting the portion indicated by the bend formula as consumed in overcoming the resistances of the bends and larger irregularities of cross section between the two localities.

The first of these errors of application causes the formulæ to apparently give too small, and the second too large results. A caution against both errors was given in the Report, but, as already stated, it has in some instances been overlooked. It should be distinctly understood that these formulæ are *not applicable to water flowing in smooth artificial channels;* and that, where bends exist in natural channels, their effect in consuming the head of water must be *taken into account by the bend formula and subtracted* before applying the other.

On page 310 Physics and Hydraulics of the Mississippi the applicability of the new formulæ for the discharge of rivers was restricted to cross sections not less than 100 sq. ft. in area, and to slopes not exceeding 0·0008. These limits were adopted, partly because they comprised all the data at hand, and partly because it was foreseen that the width must exert a certain influence not allowed for in the equations when the area of cross section was reduced much below 100 sq. ft. It appears from the new data now available that these limits of application may be considerably extended, especially in respect to the slope.

Practical Gauging of Rivers.—For practically gauging large rivers, the following has been found to be the best plan: A locality is selected in a straight portion where the water flows smoothly and without obstruction. A base line, which should rarely exceed 200 ft. in length, is laid out parallel to the current, and the exact cross section in front of this base is determined by careful sounding. To obtain the discharge, two theodolites are established, and the angular distance from, and time of transit past each end of the base, is noted for *numerous floats well distributed between the banks.* On the Mississippi, to observe 75 floats was found to be a good day's work for a party of two engineers and eight boatmen with two boats; the maximum day's work was to observe 120 floats.

The floats should be made double; the surface float being a minute tin ellipsoid, a piece of cork, or some other small light body bearing a little flag. The lower float may be a large box or keg without top or bottom, kept upright by a lead ballasting;—or, better yet because lighter, two sheets of tin bent at right angles and soldered together at the bend so as to make all the angles between the four fans right angles. Annoyance was experienced on the bar of the South West Pass from fishes seizing this latter description of float. The essential conditions are that the lower float shall so greatly preponderate in area over the upper, and shall be connected by so fine a wire or cord, that its rate of movement shall govern the whole combination.

The centre of the lower float should be placed at the *mid depth of the stream*, in each vertical plane of transit; because the rate of movement will then be unaffected by wind whether blowing strongly or gently, up stream or down stream. This very important fact was discovered during the investigations upon the Mississippi, and a knowledge of it greatly conduces to accuracy and facility in gauging rivers. It is sometimes a little troublesome to adjust to mid-depth in the different planes of transit; but with a tolerably uniform and symmetrical cross section, the average mid-depth of the river may be adopted for all the floats without sensible error. If floats passing near the surface or the bottom are used, errors in the computed discharge exceeding four per cent. may be caused by an ordinary breeze; and as these errors are positive or negative according to the direction of the wind, discrepancies of nearly ten per cent. may result in the measurements on different days, when there is no real variation in discharge. All this uncertainty is avoided by using mid-depth floats. The explanation of this fact is found in the oscillation of the axis

(horizontal) of the vertical parabola indicating the law of change in velocity from surface to bottom, under the influence of wind. The mean of this curve remains the same for a given discharge, and the curve in every position of its axis crosses the same mid-depth point; hence the ratio in question is constant, but no other is so. This continual oscillation explains many of the discrepancies which annoy observers in measuring sub-surface velocity.

The exact level of the water surface on a permanent gauge rod, should be carefully noted when the observations begin and terminate.

The following is the method of plotting the results thus obtained and deducing the discharge per second:

Upon a sheet of section paper, the base line and the two perpendiculars across which the times of transit were noted, are laid down. From the recorded angles and a table of natural tangents, the distances from the base line to the points at which each float passed both lines are plotted. These points being connected by twos, indicate the paths of the floats. Upon each path the seconds of transit—i. e. the difference between the two recorded times of transit—is written. These seconds of transit are next examined, and the total width of the river is marked off into as many "divisions" as it seems proper to assume are traversed by water moving with sensibly unvarying velocity. On the Mississippi the width of these "divisions" was uniformly assumed at 200 ft.—the total width being about 2600 ft. A mean of the seconds of transit of all the floats in each "division" is next taken, and, when reduced to velocity in feet per second, is adopted as the mid-depth velocity in that "division."

A mean of all these mean mid-depth velocities—interpolations being made if any are missing—closely approximates to the mean velocity of the river, provided the "divisions" are equal in width. This method of deducing the mean velocity from the mean mid-depth "division" velocities, involves two errors which nearly balance each other—viz., the inequality in area of the "divisions," and the difference between the mid-depth and the mean velocity in any vertical plane. The correction ratios for these errors are respectively about 0·93 and 0·98 in large rivers—giving a resulting mean velocity $\frac{0\cdot93}{0\cdot98} = 0\cdot95$ times the true value. The ratio 0·98 varies for natural channels between the limits 0·92 for a depth and mean velocity of 1 ft. and 0·99 for a depth of 80 ft. and mean velocity of 8 ft. per second. Its law

of variation is given in detail on page 293 Physics and Hydraulics of the Mississippi. The ratio 0·93 is nearly constant for ordinary river channels; its law of variation is unknown.

If a very exact computation is required—as for instance in testing the constants of a formula—the "divisions" are laid down on the plot of the cross section of the river, and the area of each is computed for the stand when the velocity observations were made. The different "division" mid-depth velocities—including interpolations, if any are wanting—are then substituted successively for $V_{\frac{1}{10}}$ in the expression $V_{\frac{1}{10}} - \frac{1}{12}\sqrt{b}\,v$ in which v is the mean velocity of the river, D the mean depth of the division, and $b = \frac{1{\cdot}69}{\sqrt{1{\cdot}5+\text{D}}}$; each result is multiplied by the corresponding area of cross section; and finally the sum of these products is placed equal to the products of v by the total area of cross section. The resulting equation contains v, $\sqrt{v}$ and known terms, and hence may be readily solved. The lesser root is the true mean velocity of the river. This method of computation gives the most accurate determination possible of the discharge of a large river. It is analogous to the plan adopted for the Mississippi, but is a slight improvement, because the peculiar properties of the mid-depth velocity were not discovered in time for use upon that survey.

A mean velocity intermediate in accuracy to those given by the two methods just described, may be computed by substituting the grand mean of the different mean "division" velocities—including interpolated velocities if any are missing—for $U_{\frac{1}{10}r}$ in the following equation, in which the value of b is that given above, D being replaced by r the quotient of a, the area of cross section, divided by p, the wetted perimeter, both in feet. The method is simple, and quite exact for ordinary river sections, but should not be applied to a rectangular section.

$$v = ([1{\cdot}08\ U_{\frac{1}{10}r} + 0{\cdot}002\ b] \tfrac{1}{2} 0{\cdot}045\ \sqrt{b})^2$$

The theory of these different methods of computing v, is explained pp. 295-296 Physics and Hydraulics of the Mississippi.

Such operations and computations as those just detailed are laborious and expensive, but are essential to the accurate gauging of a river. To determine the discharge of the Mississipi at permanent stations, cost nearly $20 per diem, before the war. At present prices,

it would cost at least $30. For these reasons, engineers desirous of ascertaining the amount of water which a given river is discharging, have been accustomed to construct a table from a set of single measurements of the amount passing at different stands of the river between high and low water; and then to deduce the discharge on any desired date, by noting the stand of the river and adopting the corresponding volume indicated by the table. This method gives results worthy of no confidence. The discharge at any given level of water surface varies enormously for different freshets, and even in the same freshet is quite different when the river is rising from what it is when falling. Near the mouth of the Ohio, when the Mississippi was about 10 feet below high water and rising most rapidly, its discharge was 1,200,000, and when falling most rapidly at this same level was 800,000 cubic feet per second—a difference of one-third! From a series of careful measurements continued daily for a river year, a table of mean discharges for each foot of the gauge rod between low and high water, may be constructed, by means of which the total annual discharge in any subsequent year may be deduced from recorded gauge readings; but such a table will furnish no means for deducing the discharge on any *given day*. It is at best a rough method and suited only for general investigations.

A knowledge of the discharge of a river both in long periods and on single dates is often necessary to the hydraulic engineer, in order to enable him to decide upon practical projects connected with its navigation, its overflows or its water power. Some economical and simple method of gauging is, therefore, a necessity; and various formulæ have been proposed to replace the costly operation of actual measurement. These formulæ were all tested carefully during the investigations upon the Mississippi; and none gave results indicating the requisite accuracy. New formulæ were framed whose precision it is confidently believed may be depended upon for practical use. Some of the grounds for this belief will soon be given, but here the point will be assumed, and the method of using them detailed. The variables which enter these formulæ require a knowledge of the mean cross section and a map of the channel between two points of the water surface, A and B, whose difference of level is exactly known. Whenever practicable, A and B should be located on a straight and regular portion of the river, the effect of bends being thus eliminated.

As this is not always possible, owing to the very gentle slope in water surface of most natural streams and especially of large rivers,

the general case will be considered, and bends be assumed to exist between A and B.

The field operations will consist in making a survey of the channel, including numerous soundings, between two permanent bench marks placed near the water at the points A and B; and in running a line of levels with the most extreme accuracy between these benches, so as to fix their relative level within a small fraction of an inch. When practicable, both banks should be occupied. These points, A and B, must be located with care as far apart as practicable, and distant from any eddy, and be placed where the current on the bank flows with *equal velocity*. The latter condition is necessary because water in motion exerts less pressure than when at rest; and if it moved rapidly past one bench and was nearly stationary at the other, a difference of level which has nothing to do with the motive power of the stream, would vitiate the observation. This matter cannot be overlooked. Baumgarten actually measured a difference of level in water surface amounting to 0·4 of a foot, between the middle of the Garonne and its right bank, where the river was only 600 feet wide and nearly straight. The corresponding difference in velocity did not probably exceed three or four feet.

In determining the mean dimensions of cross section, care must be taken to extend the soundings throughout the entire distance between the benches, A and B. Errors have often been made from forgetting that the measured fall in water surface between two stations, corresponds to the *mean channel between them*, and not to that at a short intermediate base for velocity observations. The water level, when the soundings are taken, must of course be referred accurately to the bench marks, in order to determine the area corresponding to any subsequent stand of the river.

These surveys completed, a frequent gauging of the river can be made at trifling expense. For this purpose, it is only necessary, at any desired date, to refer the water surface at A and B to the bench marks by accurate levels, and thus to determine the fall and corresponding cross section of the river—from which the discharge may be computed. Of course, it will be desirable to make a few actual measurements in order to test the applicability of the formulæ to the peculiar conditions of the river bed in question; and, if needful, to deduce a correction.

Two precautions must not be neglected in measuring the fall in water surface. The observations must be *simultaneous*, in order to

avoid the effect of any oscillation in the river, and *calm days* must be selected. The latter precaution is necessary, not only because waves render it difficult to determine exactly the level of the water surface, but also because important changes of level result from the general piling up or lowering of the water under the influence of winds. Hurricanes have raised the level of the Gulf of Mexico seven feet at the mouths of the Mississippi, and prevailing winds often produce two feet difference in that level.

The computations from such data are simple. A line following the mid-channel on the map, is drawn, composed of straight lines with angular changes, wherever necessary, of 30°. A mean velocity is next assumed (to be corrected subsequently if required) and the value of h is computed in the following formula, in which N represents the number of the deflections:

$$h = \frac{v^2 \, \mathrm{N} \sin^2 30°}{134}$$

The deduced value of h is next subtracted from the total fall in water surface observed between A and B; and the remainder, divided by the distance in feet between these stations measured on the middle line of the river, is the true value of s in the following formula for the mean velocity. The numerical values of the other variables, expressed in feet, are taken from the mean cross section. The discharge of the river in cubic feet per second is the product of this mean area by the value of v resulting from the computation. If any material error has been made in assuming v in the bend formula, the work must be repeated until the requisite approximation has been made. W is the width; the other quantities have been already defined. A table to facilitate the use of this formula is appended to this paper.

$$v = \left(\sqrt{0{\cdot}0081\, b + \left(\frac{225\, a \sqrt{s}}{p + \mathrm{W}} \right)^{\frac{1}{2}} 0{\cdot}09 \sqrt{b}} \right)^2$$

The following formulæ give the value of each variable in this equation in terms of the others and known quantities. z is equal to $0{\cdot}93\, v + 0{\cdot}167 \sqrt{b}\, v$; and when p is not known by measurement it may be assumed to be 1·015 W.

$$s = \left(\frac{(p + \mathrm{W})\, z^2}{195\, a} \right)^2$$

$$a = \frac{(p + W)\, z^2}{195\, \sqrt{s}}$$

$$p + W = \frac{195\, a\, \sqrt{s}}{z^2}$$

(To be continued.)

PENNSYLVANIA RAILROAD SHOPS AT WEST PHILADELPHIA.

By Joseph M. Wilson, C. E.

P. A. Engineer, Construction Department, Pennsylvania Railroad.

(Concluded from Vol. LXIII, page 198.)

Freight Car Repair Shop.—This building is located No. 15 on Plate I, and the elevation and plan are given on Plate XVI. It is 227 feet long by 108 feet 9 inches wide; outside dimensions, the walls being of brick and built according to the same details as previously described for the other buildings. There is only one story, and the roof is nearly flat, being supported by four rows of intermediate timber posts, 8 by 8 inches, and 10 by 10 inches section. The principal rafters are 6 by 8 inches, the braces 5 by 6 inches and the purlins 3 by 7 inches. The arrangement of framing is very simple, and is easily seen by reference to the Plate. It allows of a ventilator of 33 feet span, running the whole length of the building except on the end panels, having large glazed sash hung to swing on centres. The pitch of the roof is 5 degrees, and it is sheeted with tongued and grooved $\frac{7}{8}$ inch sheeting, covered with tarred felt and gravel. There are six large circular doors at each end of the shop, having 11 feet opening, and a corresponding number of tracks run through its whole length, and afford room for forty-two freight cars. The system of flooring is the same as in the other buildings, and work benches are fixed along the walls and between the tracks, with closets attached, for the workmen.

Water Supply.—For some years the supply of water was drawn from the city, but, in consequence of the great and increasing consumption, it was decided to erect private works. A reservoir was built on high ground, at a point marked 18, on Plate I, 60 feet in diameter and 16 feet deep, constructed of stone masonry, lined with brick laid in cement, its capacity being 338,200 gallons. A well was sunk to a gravel bed yielding a large amount of water, at No. 16, on

Plate I, and a steam pump erected. Although furnishing a copious supply, it was not sufficient for the demand, and another well was sunk at No. 17, Plate I, it being the intention to use both wells. The latter, however, furnishing a much larger supply than the former, the use of the old well was abandoned. A pipe was laid connecting the new well with the river, so that in case of necessity river water could be used, but it has not, so far, been needed.

It was desirable to avoid the use of river water if possible, it being so often impure from effects of rain storms and freshets. From experiments made in 1868, the amount of water consumed at the shops, locomotive houses and passenger stations averaged 132,100 gallons in every 24 hours, and since that time it has considerably increased. At the well there is a duplex Worthington steam pump, capable of throwing 20,000 gallons of water per hour, and two connected boilers, each 20 feet long and 30 inches in diameter.

Conclusion.—It is proposed, in conclusion, to make a general review of the different buildings, stating where we think improvements could be effected, and where we have made them in later works of the same kind. In regard to sewers, we are now using terra cotta pipe largely for all except main sewers, say up to 18 inches in diameter. We prefer those with "loose sleeves," as they have the advantage of securing a more uniform drain surface than can be obtained in pipes with fixed collars, and they also allow greater facility in removing for cleaning or repairs. Instead of cast iron hinge blocks built into the brick work for support of doors, we are using wrought iron hinge eyes, of such shape that they furnish as secure a hold and are not open to the objections of cast iron. We have adopted white pine floor beams throughout, instead of white oak, as we find that they last just as well in damp situations and are less expensive. The track stringers we still make of white oak, as they hold the spikes much better than pine. In regard to double flooring, it was originally laid in this way so that when the upper floor wore out it could be removed and renewed, the sub-flooring being saved. We find, however, that where much water is used, as in the locomotive house, it gets in between the floors and very much increases the rapidity of decay. Single flooring would, therefore, seem to be the best. From trials now being made, however, it seems probable that some variety of asphalte pavement will take the place of timber flooring altogether for shops, and prove the best material yet adopted.

In roof trusses for locomotive houses we are now using a 7 inch

deck beam, weight 58 lbs. per yard, for the principal rafter, instead of the 6 inch I beam of 40 lbs., and the struts are of wrought iron instead of cast. We also connect the trusses together at the ridge by a 7 inch deck ridge beam, weight 48 lbs. per yard, so that in case of fire, and the roof of the building burning off, the trusses will keep their places.

Gutters of double cross roofing tin, as described in the locomotive house, are now used altogether. The use of copper has been abandoned on account of the cost and the trouble caused by its great expansion and contraction under changes of temperature.

The conductors from the gutters are now always run down on the interior of the building, as it lessens the danger of freezing up in winter. Turn-tables 60 feet in diameter have been adopted for all locomotive houses.

Galvanized iron cornices have been adopted entirely for shop buildings, as a great safeguard against fire communicating from one building to another. All of our later shops are heated by steam, direct radiation, and the method has been found very satisfactory.

The pitch of roof in these shops is generally too low, and we have adopted as a uniform pitch for slate roofs, rise of roof equal $\frac{1}{4}$ the span. We are also using smaller slate than given on these buildings, the larger slate being more apt to break and cause leaks. Very good sizes are 8 by 16 inches and 9 by 18 inches. As regards the roof truss of the locomotive and machine shop, we would remark generally upon roofs, that we are adopting iron roofs wherever we can, using timber roofs only where we suspend shafting and machinery from them, the greater stiffness of the wooden tie beam being advantageous here, although we may eventually use iron even for these cases. The so-called counters, introduced in the sloping portion of the roof, Plate V, are of no use, as not necessary to the system, and should be left out. The purlins in this roof are entirely too large, three by seven inches being plenty large enough for the distance of the trusses apart.

In the second story of the store house the ventilation is not sufficient for hot summer weather, and either windows or extra ventilators should be introduced.

In the roof truss of passenger car shop some of the timbers are unnecessarily heavy, and they might be made lighter in a future roof of the same kind. We have now adopted the system of filling in the gable ends of our shops, above a line level with the eaves, with heavy

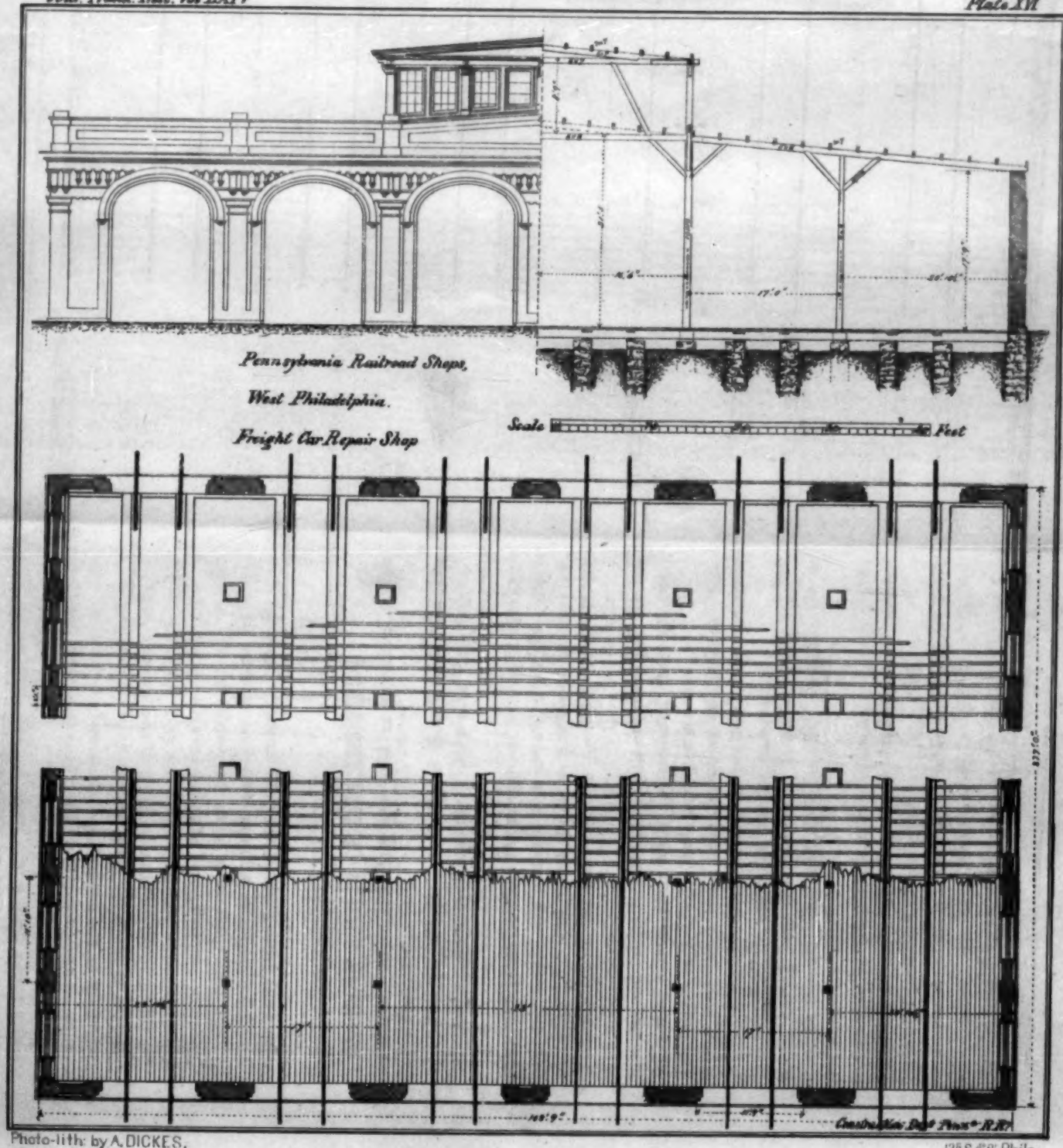


Photo-lith: by A. DICKES.

125 S. 4th St. Phila.

sash, glazed with rolled glass ¼ inch thick, adding much to the light of the interior.

In large shops we also introduce sash in the roof in long rows parallel with the length of the building and six or twelve feet wide, having the same slope as the roof. The glass used being ⅜ inch, rolled.

Freight car repair shops we are now building in a circular form, on the same principle as the locomotive house, with a turn-table in the centre, the depth of building being sufficient for three freight cars on each track. We find them much more convenient in every respect where large accommodation is required, and these circular buildings are cheaper than any other form for the same amount of floor surface.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A regular meeting of this Society was held at its rooms, in New York, January 15th, 1873.

A paper by Casimir Constable, C. E., of New York, "On Retaining Walls; an Attempt to Reconcile Theory with Experiment," illustrated by a model, was read.

A retaining wall is stable when the moment of its weight about the point of rotation exceeds the moment of a certain triangular prism of material back of the wall about the same point—the intersection of the line of rupture of the wall, and the resultant thrust of the prism.

Many formulæ and tables for retaining walls are presented for use without a factor of safety, since walls proportioned therewith, well built and carefully "back filled," have been permanent.

Experiments made on a small scale, in which the theoretic conditions were more nearly fulfiled than in practice, show that such walls are more than stable, and point out the reason why.

The problem having been thus solved, a factor of safety may be introduced in the formula, which will allow for shocks, irregular workmanship and uncertain material.

The problem may be considered under these several heads: the angle of rupture, the height of the prism of rupture, and the direction and point of application of the pressure of the prism.

Angle of Rupture.—This was first supposed to be the angle of repose with the vertical; the thrust was assumed to be horizontal, and at two-thirds the height of the wall.

Belidor assumed the angle at 45°, and that the earth moved in layers parallel to the line of rupture.

Coulomb first considered the slope of earth, with the attendant physical conditions. His theory, as amplified by M. de Prony, is discussed by M. Gauthey, who gives a clear analysis of the angle of rupture.

Supposing the resistance of cohesion is proportional to the surface of rupture, and the friction to the normal pressure, the pressure against a retaining wall is that of the prism of earth, which would at once fall if the wall were removed. The inclination of the plane of separation of this prism will vary with the cohesion and friction of different earths. If a series of planes be conceived less inclined than that of repose, and originating from the same point, one of them will have such a position that the separating prism will have need of a greater opposing force to its sliding motion than any other.

Upon this hypothesis it is proved that the prism of greatest pressure is given by the plane which bisects the angle of repose, and that

$$P = \frac{1}{2} w_1 h^2 \tan^2 \frac{i}{2}$$

in which P = the horizontal force which sustains the prism; w_1, the weight per cubic foot; h, the height; and i, the angle of repose of the prism.

Lieut. Hope found, with layers of colored sand, the average angle of rupture to be 24°, and of repose 54°. This small difference in practice from theory is probably due to the cohesion of particles, an element which, from lack of sufficient data, is generally disregarded.

Height of Prism of Rupture.—From the first it has been assumed that the wall turned over as a solid mass about the bed joint at its base. In practice it is not so; the line of rupture is a stepped line, in or near the natural slope, and leaving a part of the wall undisturbed.

For experiment, a box 16″ high and wide, and 24″ long, with glass sides, was made. A miniature wall of pine blocks or "bricks," 1″ square, 2″ and 3″ long, with a bank of oats or peas, instead of earth, in eight trials turned over as stated. When the wall began to move the face bulged out, the centre of the curve being at about one-half the height, and would continue thus until started forward by a jar. This, due to cohesion of the backing, doubtless adds materially to the stability of walls of long standing, which, it is often noticed, stand, although bulging outward. (This and subsequent statements were illustrated by experiment).

A solid wall with a joint at the place of separation was more stable than one of "bricks," for, although each began to move at the same time, the first did not continue to give way, and required to be continually started.

Navies seems first to have noticed that walls rupture in this manner. It is reasonable that the prism of pressure should start at a point above the foot of the wall, for, by rotation of the wall about the outer point in the base, the lowermost portion of the backing must be lifted.

Experiments made in the case of surcharged walls gave heights agreeing very closely with those calculated upon this basis; while assuming the prism of pressure to start from the foot of the wall would give a height far below that sustained.

Direction of Thrust.—If the weight of prism of greatest pressure be resolved into two components, one normal to the slope of rupture, and the other to the back of the wall, the first will resist by its friction the tendency to slip along the slope; the second is expressed by the formula given, and may be resolved into two other components, one inclined, the actual thrust against the wall; and one vertical, to overcome the friction along the wall. This latter, from the indefinite knowledge of the value of the coëfficient, is generally neglected. The point of application of thrust, at first assumed to be one-third the height of the prism of pressure, which gave too great thickness to the wall, has been shown by Rankine and others to be at one-third the height from the foot. The height of the prism of pressure will be from ·70 to ·75 of height of wall. The conditions of the problem are now determined, from which follow these formulæ:

$$\frac{t}{p} = -\left(n + \frac{n^1}{2}\right) + \sqrt{\frac{2\tan^2\frac{d}{2}}{7w}\left(w_1 + \frac{8p}{3}\right) + \frac{n^2}{3} - \frac{n^2}{12}}$$

in which t = thickness at top of wall, p = any weight per square foot of surface distributed over the bank, n = batter per foot in height of outside, and n_1 = the same of inside of wall; d = angle of repose, w = weight per cubic foot of masonry, and w_1 = same of earth. If n and $n_1 = o$

$$\frac{t}{p} = \sqrt{\frac{w + \frac{8p}{3}}{w}} \tan\frac{a}{2}$$

and if $p = o$

$$\frac{t}{p} = \cdot 58 \tan\frac{a}{2}\sqrt{\frac{w_1}{w}}$$

This would have been ·57 instead of ·53 in case the prism was assumed to start from the foot of wall.

Rankine's theory of earth pressures makes the thrust parallel to the surface of the bank; accepting this and these results

$$\frac{t}{p} = \cdot 57 \sin \frac{a}{2} \sqrt{\frac{w_1}{w}}$$ differing

from the usual formula in substituting

$$\sin \frac{a}{2} \text{ for } \tan \frac{a}{2}.$$

This gave results very close to those obtained by experiment, and considerably less than those from the formula last given, which, perhaps, accounts for the general omission to employ a factor of safety.

Transformation of Profiles, Vanbun's rule.—That a rectangular wall may be transformed into one of equal stability, with a batter on the face, having the same thickness at $\frac{1}{3}$th the height, is true within $\frac{1}{120}$th when the batter exceeds $\frac{1}{6}$th.

Now it is usual to give a less batter, and by taking the common thickness at $\frac{1}{10}$th the height the error is inconsiderable.

[This was proved by experiment.]

In a surcharged wall, if the surcharge starts from the back of the wall

$$\frac{t}{h} = \cdot 38 \cos a \sqrt{\frac{w_1}{w}}$$

and experiment verifies this.

Uniformly, when the experimental wall first gave way, the filling did not revolve, as stated by some writers, but settled suddenly and then rested until another shock started it again. This seems to show the advisability of stepping the back of walls.

Much depends upon the manner in which the work is done after the profile has been fixed; inattention to the details of construction may jeopardize the safety of a structure well proportioned.

For several years pains have been taken to collect data of walls in existence, with a view to establish a coëfficient, safe under ordinary conditions, and which may be modified by the engineer to suit particular cases.

DISCUSSION.

Mr. J. Dutton Steele gave a practical rule, verified by his experience, for surcharged walls of dry masonry, less than 18 feet high:

namely, a width of 3 feet at top, a batter of $\frac{1}{8}$th outside, and none inside. In one case, for a mortared wall 18 feet high, he reduced the thickness at the top to $2\frac{1}{2}$ feet, and gave a batter to both sides. Engineers who, from lack of room, have been compelled to lay walls upon narrowed or stepped foundations, will be pleased to know, from Mr. Constable's experiments, that such conform to theory, and are safe in practice.

Mr. Collingwood inquired whether it was not best to step the back of a wall, rather than give it a batter.

Mr. Constable said it was more a matter of practice than of theory, by thus stepping a wall; the back-filling, upon settlement, did not act as a wedge.

Mr. Steele said that generally now the back of a wall is not stepped as formerly, but made vertical; often in railway practice it is counter sloped or under cut, and the stability thereby increased. The back should have a "frost" batter at top, where the earth is likely to freeze, so that it may be lifted from the wall; care should always be taken, in back-filling, to slope the packed earth from the wall rather than towards it.

Mr. Colman said that in filling behind the masonry of the N. Y. State canal locks, broken stone one foot in thickness had been placed between the wall and embankment.

A communication was submitted from a prominent Canadian engineer, in which he said, "In practice I have always made my walls heavier than theory demanded, on account of the severe operations of frost in this northern latitude, where it strikes from three to four feet into the ground, and yet without giving a slope or "frost" batter to the back of the wall where the frozen earth presses against it, our strongest walls could not stand. It has been my rule to make the base of the wall equal to $\frac{3}{5}$ its height, but this is for first class masonry laid in hydraulic cement."

Mr. Constable, by experiment with the model, demonstrated that two walls of same area of section, one rectangular and the other with batter on the face of $\frac{22}{100}$, were equally stable, and also that the saving in material by giving much batter is but little. A wall battered on the back less than on the face, evidently is less economical than if all the batter was on the face.

Attention was called to the difference in resistance to crushing per square inch of section, of stones 1″ and 1½″ cube, as stated in Mr. C. B. Richard's paper, recording "Experiments on the Resistance of

Stones to Crushing," read before the Society January 8th last: thus, white marble gave a mean resistance in the first of 5812, and in the second of 8294 pounds per square inch of section. The question was raised, what relation was there between the size and the resistance of specimens, and whether tests upon blocks proportioned like those used in any particular work would better enable the engineer to determine how much the latter could withstand?

Tests of the strength of any material are of greatest value when conducted under conditions most like those governing actual use. The difficulty of making such upon large specimens was pointed out, and a brief of testing machines was given.

It was proposed to take up the latter as a subject of discussion at a future meeting of the Society.

Iron Electrotypes.—We learn from foreign journals that considerable attention is being at present directed to the production of iron plating, the result being quite satisfactory. It appears, from a consideration of the subject, that there are many purposes in the arts for which an iron plating would be superior to any of those now known in electro-chemistry.

It is stated that at the recent Exhibition (1871) at London there were exhibited bank-note plates, medallions, and a page of printing type electrotyped in iron by a process devised by M. Eugene Klien.

The importance attaching to a successful solution of the problem, especially in the direction of engraving and printing, were recognized by the inventor, who had zealously labored at the work for several years with varying success.

The medals first produced showed on their reverse side, porosities and deep hollows, which penetrated nearly through the thickness of the deposit. In the later productions these were entirely absent.

Concerning the practical application of the iron electrotype, much is expected. By replacing plates of copper by those of iron, greater facilities will be offered for producing such work as bank-notes, checks, and the like, since the iron plate is found to be almost indestructible.

Not only can they be printed from, an unlimited number of times, but they are better able to withstand those inevitable accidents to which plates are subjected in printing establishments, where often a trifling circumstance renders them useless, and involves much and often serious delay in publication.

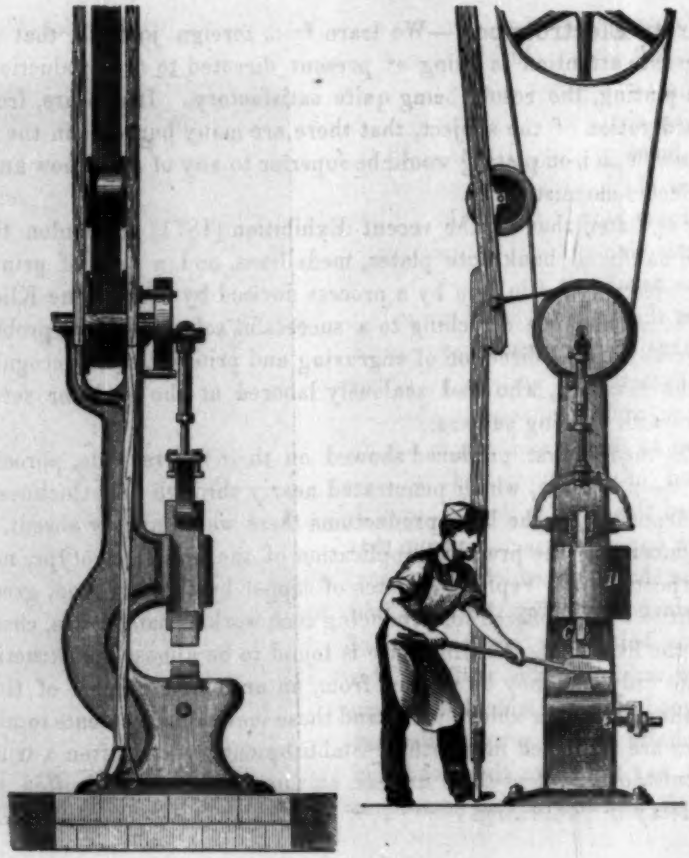
BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 105.)

Imparting and arresting motion.—Mr. Thomas Shaw's dead stroke power hammer illustrates the application of the belt for giving to and taking motion from a shaft at the pleasure of the operator. The same devices can, however, by an easy transition, be applied to other machines.

In this the driving pulley, carrying a loose belt, is on a line shaft over the driven flanged pulley, which latter is on a shaft at the top of the hammer frame. This shaft carries a crank wheel actuating the hammer, as shown, and is partly invested by a leather band for arresting its motion. One end of this band is secured to a pin in the



hammer frame under the crank wheel; the other end is fastened to the swinging lever, to which also the tightener pulley of the driving belt is applied.

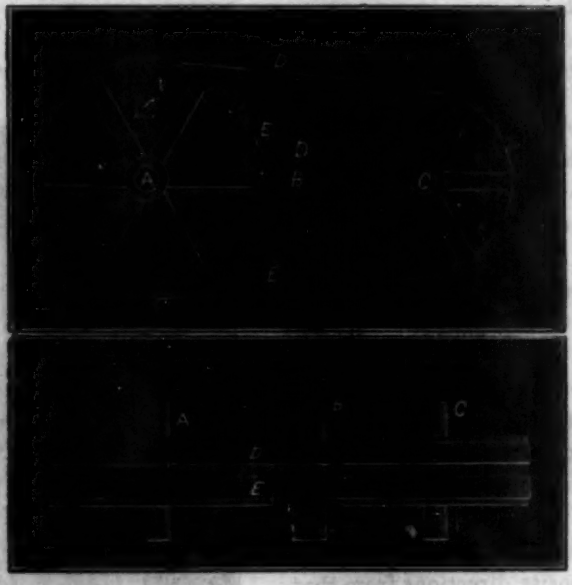
The action of these belts is produced by opposite motions of the lever; thus, when the operator pushes it, the arresting band releases the crank wheel, and the tightener pulley presses upon the driving belt, which, being constantly in motion, applies its adhesion to the pulley on the crank shaft and propels the hammer, and it does this with a varying velocity, according to the pressure upon the tightener. Withdrawing the lever relaxes the driving belt and tightens the arresting band. These motions are under the easy control of the operator, and such is the nature and action of the belt, in this application, that these motions can be repeated rapidly and effectively without destructive wear to any part of the machine.

To transmit motion from one shaft to another at right angles thereto, by a belt, when the shafts are not in the same plane.—Let E be the *driving* shaft with tight pulley, A, and loose pulley, B, and F the *driven* shaft with tight pulley, D, and loose pulley, C; all the pulleys of same size and with rounded face in the usual way.

Let the pulleys be arranged in a square on the plan, whose side is the diameter of pulleys at centre of face, and let an endless belt be put on as shown and run in the direction of the arrow. It will be noticed the loose pulleys, C and B, run in opposite directions from that of the shafts on which they turn, but since they carry the slack fold of the belt, they are relieved of heavy strain on the shafts. This is a good plan for wide belts when the shafts are a proper distance apart, say ten times the breadth of the belt, and solves that sometimes

difficult problem of carrying considerable power around a corner by a belt. There is no loss of contact of the belt on any of the pulleys of this system, and no lateral straining and tearing of the fibres of the belt as in the usual quarter twist arrangement in which only two pulleys are used. The lower shaft may drive the upper one, as well, by changing the direction of motion, or changing the relative positions of the tight and loose pulleys.

Weaver's belting.—The object of this arrangement is to obtain high speed in a shaft directly from a driving pulley without the aid of intermediate counter pulleys or gears, and with reduced lateral stress on the bearings of the driven shaft.



A, B and C show three shafts parallel to one another. A and C carry straight-faced pulleys, upon which run two belts of equal length and width, separated to prevent contact with each other while running. The lower fold of belt, D, is carried *over* the shaft, B, and the upper fold of belt E is carried *under* B, and each, in running, imparts motion to the driven shaft in the same direction, and at the same time balancing the lateral pressure on its journals.

A is the driving shaft with large pulley; B the driven shaft of comparatively small diameter, and C, a counter shaft, with its pulley

of any convenient diameter, is placed in position to carry and return the belts, and may be moved and secured to and from B by screw adjustment or otherwise, to secure proper tension of belts.

Combined fast and loose pulley for round belts, by John Shinn, of Philadelphia.—The round belt, *f*, fits in a groove formed between two half pulleys, of which A′ is fixed and A slides upon a fixed key on the shaft, B; between A′ and A, and running loosely on the shaft, is a flat-faced pulley, C; when A is separated from A′ a short distance, the belt, *f*, will cease to turn them, and will run on and turn C instead. The belt drives the shaft, B, only when pinched between the half grooves of A′ and A. The lever, D, when moved in the direction indicated by the arrow, withdraws the half sheave, A, and permits the belt to run on the loose pulley. Simple and efficient means for holding the parts together and drawing one half from the other, are shown in the cuts.

Fig. 1

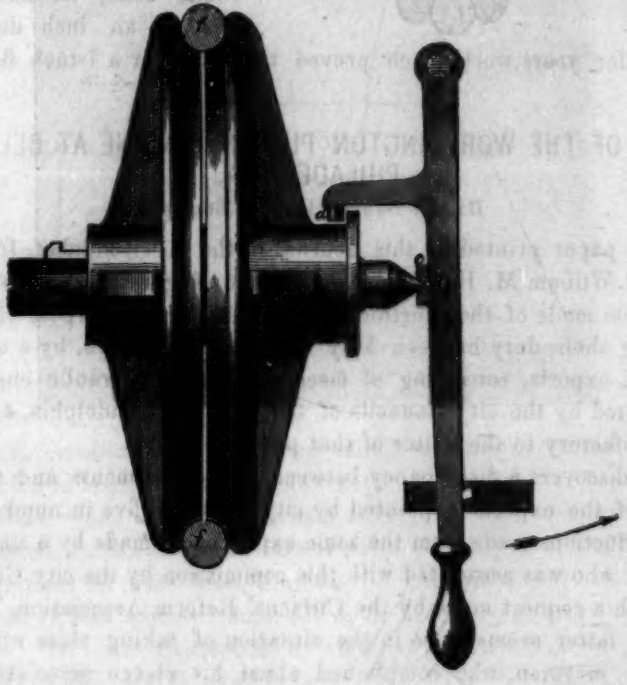
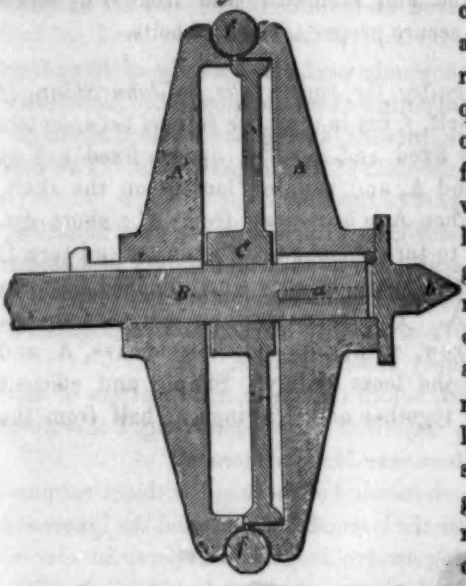


Fig 2



It is not proposed, of course, to drive very large and heavy machinery with round belts, such as are required for this description of shifting pulleys; but, as far as a round belt will go with advantage, these pulleys will be found of the greatest service. Thus, the round belt cuts off less light, occupies less room, makes smaller holes in the floors, requires lighter driving pulleys to carry it, and thus saves power; while, as regards the driving power of round belts, we have seen one, of an inch diameter, doing for years work which proved too much for a 7-inch flat belt.

TEST OF THE WORTHINGTON PUMPING ENGINE AT BELMONT, PHILADELPHIA.

By W. Barnet LeVan, Engineer.

In a paper printed by this Journal in the April number, from the pen of William M. Henderson, Hydraulic Engineer, it appears that the tests made of the Worthington engines for the purpose of ascertaining their duty between May 15th and 17th, 1872, by a commission of experts, consisting of mechanical and hydraulic engineers, appointed by the city Councils of the City of Philadelphia, are very unsatisfactory to the writer of that paper.

He discovers a discrepancy between the experiments and calculations of the experts appointed by city Councils, five in number, and the deductions made from the same experiments made by a single engineer, who was associated with this commission by the city Councils, through a request made by the Citizens' Reform Association.

The latter seems to be in the situation of taking sides with that twelfth juryman, who complained about his eleven associates, who were so contrary that they did not agree with him.

Five gentlemen say that these engines actually performed a duty of fifty four millions four hundred and sixteen thousand six hundred and ninety-four pounds.

One gentleman says that they only performed a duty of forty-four million six hundred and seventy-nine thousand pounds. A majority of these five gentlemen were present during the whole forty-eight hours and twenty minutes—the time of the experiments. The one gentleman was present only *part* of the time.

Now it would seem that under general principle the determination, by experiment, of so simple a problem as that of the duty of a steam engine, pumping water up hill, ought to be satisfactory to every body, particularly as these gentlemen are highly learned and distinguished for their knowledge of machinery and hydraulics.

But, since it has been found, before to-day, that, in matters of science and the engineering art, majorities have been wrong, I therefore conclude, by a short paper, to answer Mr. Henderson.

His calculations put me much in mind of those old arithmetical puzzles, that are invented to amuse the learned and confound the ignorant. One of them is that of putting twelve lodgers in a hotel in eleven beds, one bed in each room and eleven rooms, and only one in each bed.

What duty means.—Mr. Henderson states that where he uses the word duty he means the same thing as the commission of experts meant, namely, the number of pounds of water raised one foot high by the consumption of one pound of coal; he refers to the Charlestown water works for the past year, which gives the average duty of the Worthington Duplex Engines at about 70,000,000 pounds.

It appears that this pump at Charlestown, smaller and more insignificant, as compared to the Belmont pump, made and placed there by the same maker, Mr. Worthington, has produced a duty of about seventy millions.

It would seem most natural that these five contrary men, in making the test at Belmont, with pumps and machinery placed by the same maker, of larger capacity, with finer appliances, with better mechanical attachments; it would seem strange, I say, that the Belmont pumps should not do somewhat near an equivalent duty to those at Charlestown.

The price bid.—He speaks incidentally of the price of the bid of a New York firm for ninety-five thousand dollars, and that of the Messrs. Merrick fifty-seven thousand dollars.

The casual reader would understand, most likely, that these bids were for the same work—indeed, his paper says so—while the truth is that the form, character and duty of these engines, as guaranteed by these gentlemen, were as wide apart as their bids were.

Annual Duty.—The duty, called the annual duty by the writer of the paper under discussion, as he determines it from the reports of the late Chief Engineer, is 38,000,000 and a fraction, and he complacently says, "Now the duty of these engines are pretty well established," and that "the duty of 67,969,000 has not been obtained and cannot be obtained," and therefore the report of these five experts is either the work of a set of ignoramuses, or is a deliberate fraud upon the public.

In the first place, the test of duty, under the contract with Worthington, was to be for a duty of fifty millions pounds in twenty-four hours continuous run; height 208 feet, exclusive of friction.

The duty to be determined was the maximum duty of the engines, the same as in the purchase of a horse that is guaranteed to trot a mile in 2′ 18″.

The contract is filled if the horse performs that amount of duty.

Coal.—Coal to be used for a test should be screened, and should be of the best quality. Otherwise, if leaway were to be given as to the quality of coal to be employed in the test, advantage might be taken of the engine builder by furnishing the poorest, dirtiest and most worthless quality of coal to be employed for the test.

The test.—A test should be made in the beginning by starting with clean fires, and at the close the fires should be in the same condition as at commencement. The amount of water evaporated per pound of coal consumed is an incidental affair, and has nothing to do whatever with the duty or work of the engine. *The elements of the work of the engine is the amount of weight it has raised to a certain height by a certain number of pounds of coal.*

Therefore, whether the engine evaporated 9½ or 7½ pounds of water to a pound of coal, is not in the question of the duty of this engine.

Ashes, coals, &c.—As to calling one-third of the ashes, coals (1450 lbs.), that was a matter of the judgment of five experts against one, as five contrary men to one.

Forcing engines.—Forcing the engines continuously to within five-sixteenths of an inch of the cylinder heads, showed how exquisitely fine their mechanism was.

Manipulation of feed pump.—The several witnesses who saw a

manipulation of the feed pump which supplied the boilers with water, were the five witnesses who did not see it, and the one witness who was not there and *did* see it.

Error at weir.—As to the error detected by the citizens' expert in the measurement of water delivered over the weir, it is but fair to be said that the citizens' expert saw the weir but occasionally, while the majority of the five experts and their assistants saw it every five minutes for the entire forty-eight hours and twenty minutes.

Capacity of pumps.—*The capacity of the pumps* are not independent *of the actual delivery of water into the reservoir*, because that capacity in work done is what delivers water into the reservoir.

The writer (Mr. Henderson) of the paper I am criticizing will understand that there is no enacting of a tragedy of Richard with "Richard left out" in the pumping of water by steam. He knows, as well as I do, that if he makes his Richard a steam engine, and leaves him out, no water will ascend the hill.

Height of main.—The writer says that the height of the force main is 217.14 feet, and that is incorrect, and that the height is actually but 208 feet. It is unnecessary to say to the scientist that the difference is the extra height due to friction, which these five contrary men determined upon.

The annexed indicator diagram, taken from rising main just as the water left the pumps, shows the working conditions of the pumps.

Captain Loam, who has had a large experience in the testing of Cornish engines, stated to a large engine builder in this

city, that when a test was to take place, preparations were made weeks in advance, and then the trial only lasted a short time, and the delivery was arrived at by calculations, and not by measurement.

It will be seen by the above that the average duty of the Cornish pumping engines is near about from thirty to forty million pounds; that the high duty mentioned by Mr. Henderson refers to those Cornish pumps that draw their water from deep mines, from 1,000 to 2,000 feet in depth.

Their process of working is simply the act of lifting the water from these deep pits by a slow and easy process, the steam acting only to raise the heavy weights that are attached to the long line of rods and pumps that extend into the deep pits below.

The strokes of these engines are generally regulated about in the proportion to the water that flows into the mine, and generally they run at the rate of from one stroke in a minute to one stroke in five minutes.

Therefore, I say that the comparison, as instituted between the Holmbush engine and that of the engine as at Belmont, is as though one were to make a comparison between the duty performed by a giant doing a small amount of work in proportion to his strength, and the little worker, who is active, determined, efficient and accomplishes much more by the expenditure of less vital force. The writer of the paper which I criticise says that he considers it a duty to place the subject of the test of the Belmont pumps in its proper light before the community.

I am afraid that his light is simply the single light (sperm candle, as I suppose), overshining the lights of those five contrary men who seem to believe that if you lift 93,485,513 pounds of water 208 feet high, adding nine feet for friction, by 38,890 pounds of coal, results in 54,416,694 duty. I am afraid that his light, however so brightly it may shine, will not do otherwise than show that this awkward set of ignoramuses, who determined the duty of these engines, both by experiment and calculation—these five men, who were so contrary and who chose to differ with this one man, were right.

I think it will be clear that if the test is made again, which the writer, Mr. H., so particularly desires, it will be found that these five contrary men were right.

I append below a copy of the letter from the gentleman who furnished the coal for the experiment. He declares that it was only ordinary coal. It should have been, by rights, properly screened and picked for the experiment, for that was but simple justice, if it had

been so done, to the manufacturer of the engines at Belmont. But it was not so done.

Philadelphia, April 4th, 1873.

PHILADELPHIA, *July 24th,* 1872,
314½ Walnut street.

F. GRAFF, Chief Engineer City Water Department.

Dear Sir:—In reference to the coal spoken of in H. P. M. Birkinbien's report of the trial of the Worthington pumps at Belmont, we would say that the coal was shipped direct from the mines in cars No. 1484, 2942, 4362, 2699 and 2617, April 20th, and was delivered in your schute at the works April 23d, by the Pennsylvania Railroad Company. The coal was the ordinary run of the mine, and was sent without any extra care or preparation whatever, and the same quality can be had at any time or in any quantity by simply giving the order; therefore the assertion in the report that the coal was prepared for the occasion, is simply a misstatement. The coal was from the Shawnee colliery, near Wilkesbarre.

Very respectfully yours,
[Signed] W. D. HESTON, & Co.

The coal referred to above was wheeled into the engine house near the scales immediately upon its arrival, that it might be convenient for use. I certify that it was not "*selected, screened or picked,*" as represented by Mr. Birkinbine.
[Signed] FRED. GRAFF,
Chief Engineer Water Department.

NOTES ON THE RESISTANCE OF BRICKS TO A CRUSHING FORCE.*

BY GEORGE S. GREENE, JR., C. E.

The bricks were of the kind used in the construction of the South Gate-House of the New Reservoir in the city of New York, by Fairchild, Walker & Co., contractors.

The experiments were make by Gen. George S. Greene, at Cornell & Co.'s, Centre street, September 20th, 1860, in Hatfield's Hydraulic Press for testing building materials, built by R. Hoe & Co.

The bricks were what are known as hard brick, and manufactured at the yard of Wm. Call, Haverstraw, on the Hudson river; they are regarded as average samples of the mass of brick used in the construction of the Gate-House. The experiments were not made in the interest of any person, but solely to determine the actual strength of the brick. In order to bring them within the power of the machine, but little more than half of a brick was used. The pieces of brick were

* From American Society of Civil Engineers.

first dressed by a stone-cutter, and then ground down on a grind-stone. The faces exposed to pressure were not perfect planes, and therefore a layer of wood and sand was interposed between the faces of the machine and those of the bricks.

Dimensions of the Brick used in Experiments, in Inches and Decimals.

	THICK. WIDE. BROAD.	
No. 1.—2.30 x 3.52 x 4.40	15.488 sq. in.	exposed to pressure.
No. 2.—2.24 x 3.50 x 4.46	15.610 "	" "
No. 3.—2.34 x 3.50 x 4.52	15.820 "	" "
No. 4.—2.34 x 3.46 x 4.46	15.4316 "	" "
No. 5.—2.30 x 3.46 x 4.50	15.570 "	" "
No. 6.—2.28 x 3.46 x 4.60	15.916 "	" "

No. 1.—At 30,000 lbs. (= 1.937 lbs. per sq. in.) cracked in centre; kept at 50,000 (= 3,228.3 lbs. per sq. in.) without crushing. Brick between two pieces of board, half an inch thick.

No. 2.—Had a layer of sand. Sign of crack at 50,000 lbs.(= 3,203 lbs. per sq. in.); kept at 52,500 (= 3,362.2 per sq. in.) for three minutes, but did not crush. Crack did not extend through brick, nor was it broken into two parts.

No. 3.—Crushed to pieces at 43,500 lbs. (= 2,749.7 lbs. per sq. in.); packed with sand.

No. 4.—Packed with two pieces of cigar-box wood; edges crushed off at 30,000 lbs. (= 1,994.1 lbs. per sq. in.)

No. 5.—Packed with sand; cracked at 27,000 lbs. (= 1,734.1 lbs. per sq. in.); crushed at 32,000 lbs (= 2,055.3 lbs. per sq. in.) Brick crushed and cracked in all directions; did not fall to pieces as did No. 3.

No. 6.—Packed in sand; commenced to crack at 30,000 lbs. (= 1,884.9 lbs. per sq. in.); crushed to pieces at 46,500 lbs. (= 2,921.6 lbs. per sq. in.)

An Indelible Ink.—M. Böttger has published the observation that an excellent indelible ink can be prepared by taking a quantity of aniline black, triturating the same in a porcelain mortar with a few drops of alcohol and hydrochloric acid, and mixing it with a hot solution of gum arabic. The same observer declares also that if, instead of gum arabic, shellac is employed, the preparation will make an excellent enamel for wood and leather.

EXPERIMENTS ON THE RESISTANCE OF STONES TO CRUSHING.*

By C. B. Richards, M. E.

The accompanying tables present the data and results of experiments made by direction of General Franklin, at the Colt Company's Armory, to ascertain the relative resistance of various American building stones to crushing.

The specimens were furnished by Mr. J. G. Batterson, and were shaped with great accuracy at his marble works in this city. They were selected from old and dry stones of the best quality of their kinds, and were worked into nearly perfect cubes with very flat and smooth faces. Two different sizes of cubes were tested, their edges measuring very nearly one inch and one and a half inch respectively.

The testing machine used in the experiments is one designed by the writer for the Colt Company, who had it constructed for use in their Armory, both for testing materials used in their own manufactures, and also for making tests for the engineering public. As a description of this machine was published in the "Scientific American," of March 26th, 1872, and in several other mechanical periodicals, it is unnecessary to describe it here; it is only desirable to state that the apparatus for weighing the strains consists of a very sensitive platform scale of fifty tons capacity, and that the machine was built after a long experience with two smaller, similar machines, one of which was constructed by the writer as early as 1867. Experience with this large machine in operating on hundreds of specimens, has proved it to be admirably adapted for accurate research, and leaves no room for doubt as to the correctness of its indications.

The fixtures between which the stones were crushed consist of hardened steel hemispheres, with their curved surfaces seated in corresponding cavities made in steel blocks, which are fixed in the testing machine. These hemispheres can rock in every direction, and their flat surfaces, therefore, accommodate themselves to the direction of the surfaces of the specimens.

Single thicknesses of thin "lace" leather were applied between the steel and stone surfaces to ensure uniform distribution of the pressure upon the specimen.

The pressure was in all cases applied to those surfaces of the cubes which were parallel with the natural bed of the stone.

Table 1 gives the description and dimensions of each specimen, the strain required to crush it, and the resistance per square inch deduced from the area crushed and the crushing strain.

* From American Society of Civil Engineers.

The sides of the cubes and their dimensions referred to in the table, columns 3, 4, 5 and 6, are indicated by letters, as shown in this diagram.

The side on which the pressure was applied is shown in each case in the table by the letter in the sixth column. The area of the surface on which the pressure was given, will there be obtained from two of the three dimensions given in the third, fourth and fifth columns, as follows:

$$\text{If the pressure was exerted on } \left\{ \begin{matrix} a \\ b \\ c \end{matrix} \right\} \text{ the area} = \left\{ \begin{matrix} a \times b \\ b \times c \\ c \times a \end{matrix} \right\}$$

Table 2 exhibits a resumé of the results of all the tests, grouped according to the kind of stone and size of specimen; giving the minimum, average and maximum resistance per square inch of all the specimens of each kind.

All the specimens failed by breaking up into slender prisms and pyramids whose axes were normal to the surfaces on which the pressure was exerted. Specimen, No. 8 (Table 1), split into four parts with a strain of 6,250 lbs., and afterwards sustained an additional load of 5,210 lbs., without other indications of failure.

Several other specimens split into two or four nearly equal parts, with loads somewhat less than those which ultimately produced crushing.

In all cases the strain was gradually applied, and increased to the crushing point by pouring shot into the apparatus by which the pressure is produced.

It will be noticed that several of the specimens broke with strains of even thousands of pounds. This coincidence probably arises from the fact that it requires some seconds of time to move the large weight on the weigh-beam of the testing machine, and this needs to be moved for every two thousand pounds increment of strain (the intermediate pressures being otherwise indicated at the beam). While this change is being made, the strain then exerted is maintained unaltered, while at other times the strain is continually though slowly increasing. It is reasonable to suppose that if the specimen is slowly giving way while the adjustment of the weight is being made, opportunity is then given for it to yield and fail at the pressure then on, which will be at some certain thousand of pounds; but if the strain had been slowly increasing during the time while the specimen was yielding, the indication of the machine would have been a few pounds higher.

Hartford, Ct., January, 1873.

TABLE 1.

No.	KIND OF STONE.	Dimensions. A	B	C	Side on which the press'o was appl'd.	Pressure at which crushing occurr'd.	Resist'e to crushing per square in.
		in.	in.	in.		lbs.	lbs.
1	White Marble from Canaan, Ct.....	0.980	0.990	0.990	*a*	4,810	4,958
2	do. do.	1.000	0.963	0.980	*b*	6,280	6,654
3	do. do.	0.990	0.998	0.963	*a*	5,000	5,060
4	do. do.	0.997	0.990	0.992	*a*	6,500	6,585
5	White Marble from Alford, Mass.....	1.000	0.998	1.005	*a*	5,000	5,010
6	do. do.	1.002	1.005	1.004	*b*	3,940	3,905
7	do. do.	1.000	1.005	1.000	*a*	5,990	5,960
8	Blueish Marble from Lee, Mass.....	0.995	0.999	0.998	*a*	11,460	11,528
9	do. do.	0.984	0.998	1.000	*b*	7,690	7,705
10	Granite, from Westerly, R. I.....	1.000	1.008	1.004	*b*	19,000	18,778
11	do. do.	1.002	1.005	1.000	*a*	15,700	15,596
12	Granite, from Plymouth, Ct.....	1.000	0.993	0.995	*a*	8,560	8,620
13	do. do.	0.997	0.995	0.997	*c*	10,350	10,412
14	Granite, from Concord, N. H.....	1.000	1.000	0.985	*c*	8,680	8,812
15	do. do.	1.002	0.983	1.003	*a*	9,690	9,838
16	White Marble, from Alford, Mass.....	1.000	1.004	0.997	*a*	6,000	5,976
17	Granite, from Quincy, Mass.....	1.001	1.001	1.004	*c*	15,700	15,622
18	do. do.	1.005	0.996	1.001	*c*	13,000	12,923
19	do. do.	1.001	0.997	1.003	*b*	11,730	11,730
20	Granite, from Fox Island, Maine.....	1.000	1.004	0.987	*c*	14,000	14,185
21	do. do.	1.000	1.001	1.005	*c*	12,360	12,299
22	do. do.	1.007	1.000	1.005	*b*	12,900	12,836
23	do. do.	0.995	1.004	1.002	*a*	11,880	11,892
24	Granite, from Jonesboro, Maine.....	0.990	1.007	1.006	*b*	11,380	11,233
25	do. do.	1.007	0.994	1.005	*a*	12,320	12,307
26	do. do.	0.996	1.005	0.998	*b*	16,000	15,952
27	Sandstone, from Amherst, Ohio	1.002	0.988	0.995	*c*	7,740	7,463
28	do. do.	0.985	0.998	1.000	*c*	8,350	8 477
29	do. do.	0.992	0.991	0.999	*c*	8,050	8,123
30	do. do.	0.988	0.996	1.009	*b*	9,000	8,955
31	do. do.	0.996	1.002	1.004	*b*	6,180	6,141
32	Sandstone, from Portland, Ct.....	0.993	1.003	1.006	*c*	5,800	5,806
33	do. do.	1.002	0.985	0.993	*a*	6,240	6,322
34	do. do.	1.004	0.997	0.996	*a*	8,260	8,252
35	do. do.	1.001	1.001	1.001	*a*	10,950	10,928
36	Sandstone, from Nova Scotia.....	0.993	1.006	0.998	*c*	10,220	10,322
37	do. do.	0.999	0.997	1.005	*a*	7,130	7,158
38	do. do.	1.011	0.997	0.998	*b*	6,500	6,532
39	do. do.	1.005	0.998	0.998	*a*	9,220	9,193
40	do. do.	1.005	0.999	0.996	*b*	9,320	9,366
41	White Statuary Marble, Carrara, Italy..	1.494	1.487	1.493	*a*	21,600	9,723
42	White Marble, from Canaan, Ct.....	1.476	1.483	1.493	*a*	19,250	8,794
43	do. do.	1.487	1.479	1.484	*a*	17,140	7,793
44	Sandstone, from Windsor, Ct.....	1.489	1.488	1.484	*a*	22,000	9,929
45	do. do.	1.495	1.484	1.488	*a*	27,850	12,553
46	White Marble, from Derby, Ct	1.489	1.486	1.466	*b*	21,300	9,777
47	do. do.	1.486	1.478	1.490	*a*	18,900	8,605
48	Blueish Marble, from Lee, Mass.....	1.475	1.485	1.480	*c*	30,460	13,953
49	do. do.	1.480	1.476	1.483	*b*	39,300	17,954
50	White Marble, from Lee, Mass.....	0.993	0.998	0.988	*a*	12,800	13,916
51	do. do.	0.992	0.990	0.983	*b*	13 900	13,972

TABLE 2.

KIND OF STONE.	LOCALITY OF QUARRY.	Number of Specimens crushed of each kind.	Nominal size of Specimens.	Resistance to Crushing per Square Inch.		
				Minimum.	Average.	Maximum.
			in.	lbs.	lbs.	lbs.
White Marble	Canaan, Ct.	4	1	4,958	5,812	6,585
do.	do.	2	1½	7,794	8,294	8,794
do.	Alford, Mass.	4	1	3,905	5,213	5,976
do.	Lee, Mass.	2	1	12,917	13,444	13,972
Blueish Marble	do.	2	1	7,705	9,616	11,528
do.	do.	2	1½	13,953	15,953	17,954
Granite	Westerly, R. I.	2	1	15,591	17,184	18,778
do.	Plymouth, Ct.	2	1	8,620	9,516	10,412
do.	Concord, N. H.	2	1	8,812	9,325	9,838
do.	Quincy, Mass.	3	1	11,730	13,425	15,622
do.	Fox Island, Maine	4	1	11,892	12,803	14,185
do.	Jonesboro, Maine	3	1	11,234	13,164	15,952
Sandstone	Portland, Ct.	4	1	5,806	7,826	10,928
do.	Amherst, Ohio	5	1	6,141	7,832	8,956
do.	Nova Scotia	5	1	6,532	8,512	10,322
do.	Windsor, Ct.	2	1½	9,930	11,241	12,553
Statuary Marble	Carrara, Italy	1	1½	.....	9,723	.....

APPENDIX.

The following additional communication from Mr. Richards, in reply to some inquiries, is here printed:

With reference to these experiments on stones, one object in having the specimens made of two different sizes, was to attempt to ascertain whether the size would affect the modulus of rupture. It was anticipated that the larger cubes would give the higher results, and this seems to be the fact. But, in the communication, attention was not called to this circumstance, because it can hardly be supposed that reliable average results can be obtained from a test of only two specimens, and there were no more than two of the large specimens of any one kind of stone. This doubt would apply particularly to cases where the extreme results vary so greatly as those in question. It is to be noticed in the tables that in some cases the minimum modulus for the large cubes is smaller than the maximum for the small ones of the same kind of stone.

It would be interesting to learn where the limit is, when an increase of the size of the specimen ceases to affect the modulus derived from the experiments. But I imagine that this limit would vary with the

different kinds of stone, and that the solution of the question would require a testing apparatus of considerable capacity. That the relative proportions of the specimens be made to correspond with those of stones commonly used in practical work, is undoubtedly important, and ought to be carried out. It seems probable, however, that even in this case, the thickness of the experimental piece ought to be considerable, say at least one and a half inches for some kinds of stone, and this would involve a large area to be crushed, and consequently require the application of great strains.

The more any one makes test of the strength of materials, the more he realizes the importance of being able to test large samples, and of having powerful testing machines, such as Kirkaldy's.

Since this communication was prepared, my attention has been called to experiments made by the Commission of 1851, on marbles, &c., for the United States Capitol Extension (see Architect's report, accompanying the President's message, 32d Congress, 2d Session, 1852.)

This Commission discovered the somewhat remarkable fact that the effect of pieces of sheet lead placed between the stone samples and the steel surfaces of the testing apparatus, was to occasion the failure of the specimen with about half the load it would sustain if pressed directly by the steel surfaces; that is, with the steel and stone surfaces in contact.

Now, in my experiments, thin leather was used between the stone and steel surfaces as stated. This leather must have become practically rigid under the pressure it sustained, as seems to be proved by the way the specimens broke up into numerous slender pyramids, and by the friable character of the whole substance of the fractured parts, which can in most instances be crushed to powder between the fingers. These conditions of the broken pieces seem to indicate that the pressure was applied in a way that caused all parts of the specimens to fail at the same time, which must be the case when steel surfaces are applied fairly to the stone. With lead interposed, the circumstances are different, because this metal retains its sotfness at such pressures as those in question.

THE MEXICAN METHOD OF MAKING HARD LIME FLOORS.*

By Gen. Theo. G. Ellis, C. E.

Some years since, the writer had occasion to visit Northern Mexico, to examine and work some silver mines; and, while passing through the Mexican villages, noticed the exceedingly hard and polished lime floors and roofs of the houses.

In the village of Salinas, where our party remained some three weeks, the horses passed daily through the house into the inner court-yard over one of these floors without leaving an indentation, or injuring it in any way. Some time after, having occasion to construct some buildings at La Yguana mines, an attempt was made to imitate these floors and roofs. Attributing the peculiar hardness and smoothness of the floors to the inherent good qualities of the lime used, no inquiries were made as to the Mexican method of working. A good quality of limestone was selected and calcined in the ordinary way. Shortly after burning it was slaked to a dry powder, and afterwards used as required. A floor was laid with a foundation of about three inches of broken stone, over which was evenly spread about two inches of mortar, formed of two parts of clean sharp sand, and one of lime. The lime was "fat," swelled greatly in slaking, and was not at all hydraulic.

The floor, made as above, was a total failure. At the end of four weeks the leg of a chair would indent it. As soon as the surface was damaged it began to crumble; and soon broke up. It would probably have been about as hard as our ordinary lime mortar if allowed to set a sufficient length of time before being used.

Knowing that the Mexicans used the same materials with better success, their superior skill was called into requisition to lay all the remaining floors and roof of the same building. They used the same sort of lime and sand in about the same proportions, and upon the same kind of foundation. The result was a floor as hard and smooth as a piece of polished marble, that a horse could trot upon without injury.

A brief account of the method of making these floors may not be uninteresting.

The limestone used was a hard, compact blue material, in some places sufficiently hard to strike fire on the drills used in running a

* From American Society of Civil Engineers.

drift through it for mining purposes. It often contains iron pyrites in small proportion. This was calcined in kilns cut out of a very soft limestone, that likewise is found in that section of country, and which on account of its whiteness and softness is called "cal leche." I believe it is never used for making lime by the Mexicans.

After calcination the lime was removed from the kilns and slaked as soon as cool. Some of it was used within a day or two, and some remained a month or more in barrels. All the work made with it seemed to be equally good.

In making the floors, a layer of broken limestone, three or four inches thick, was first laid evenly over the surface of the ground. The stone being about the usual size for macadamizing roads; over this a mortar of about two parts of sand to one of lime was carefully and evenly spread to the thickness of one and a half to two inches; this was allowed to remain for about twenty-four hours, or until the surface had become quite dry. It would probably take longer in this climate, where the air possesses a greater amount of moisture than in Mexico.

The floor was then thoroughly pounded all over with a tool composed of a block of wood about a foot square and three inches thick, having a handle rising from the middle, so that a man could stand while using it. The whole surface was beaten over with this ram until it was again as soft and moist as when first laid. This operation of ramming brought the water in the mortar to the surface so as to form a layer of semi-fluid substance on top.

The floor was again allowed to dry, and again beaten over each day for about a week, when the operation brought only a slight amount of moisture to the surface.

Immediately after the last pounding the whole surface was powdered with a thin layer of red ochre, evenly sifted on, and then polished as follows:

A smooth, nearly flat, water-worn stone, a little larger than the fist, was selected from the bed of the stream which ran through the place, and with this the whole floor was laboriously gone over, rubbing down and leaving the surface of the lime as smooth as a piece of polished stone; the red of the ochre rendering it of a rich brown color.

In less than a week the floors made in this way were sufficiently hard to bear the weight of a horse without indentation.

Roofs were made in the same manner without the coloring matter, which was added only to give the floors a better tint than the gray of

the mortar. These roofs were perfectly water-proof, and were unaffected by sun or rain.

In the city of Monterey, sidewalks in the principal streets are made in the same manner, and some of them have lasted for years, wearing through like a block of stone.

The great durability and strength of these floors and roofs is entirely owing to the pounding operation above described, as the same materials were tried in the ordinary way without success.

The writer has not had occasion to make use of this process in this climate, but gives a description, hoping that it may be of value to others who may have occasion to lay floors of lime in architectural or engineering works. He has never heard of this method being employed in this country; although it seems singular that it should be used so generally by a neighboring nation, and be wholly unknown to our builders.

APPENDIX.

The following correspondence, growing out of the above, is here printed:

From Estevan A. Fuertes, C. E., Member of the Society.

A paper read before the Society, upon a Mexican method of consolidating mortars, described as of extreme hardness, suggested to my mind that, perhaps, its author might be mistaken in attributing its main durability and hardness to the slow system of consolidating the road-bed and its cover.

My doubts have grown out of the circumstance that the author says (without seeming to attach much importance to the fact), that ochre or a similar pigment, was mixed with the mortar.

I think that the coloring matter, believed to be of secondary importance, is the main ingredient which determines the superiority of the cement described; and instead of its being ochre, it was underburnt brick dust.

If I am not the one who is mistaken, the consideration of this subject will bring up for discussion the method of obtaining a cheap and superior cement, that, I believe, has not been used much in this country.

The Hydraulic Engineer has much need of studying the causes which induce the "setting of mortars," because it is almost certain that the resistance of such materials as bricks, limes and cements, depends upon their conditions of crystallization.

I am aware of only two methods of hardening the silicates usually

employed in hydraulic works, viz., the gradual chemical change (crystallization in the slow, humid way, as in submerged foundations, etc.), and the quick vitrification under the influence of intense heat, as employed in brick-making.

It is notorious that under-burnt brick resists very badly the influence of atmospheric wear, especially near salt water. I have crumbled in my hand an under-burnt brick, one year after its exposure to the sea spray, and gunpowder was manufactured from the nitrate of potassa formed upon its porous substance; but the same clay burned with chalk, making a double salt of carbonate of lime and silicate of alumina, or rather a sub-crystalline double silicate of lime and alumina, after being ground, made a cement susceptible of receiving a splendid lustre, and withstood the action of the spray and of the waves without apparent change.

Both the limestone and the brick had been used separately as building material in a burying ground near the sea shore, where the experiments were conducted in 1861. Eighteen months of exposure for the stone and twelve months for the brick, were sufficient to render both materials useless; but when burnt, ground and mixed, they stood much better than the finest and distinctly crystalline marbles.

At the end of three years, or more than the sum of the times of durability of each material, I left the place where the experiments were made, and then the cement had not changed where the surface had been left rough, nor tarnished where it had been polished.

A cement called "Revocado" by Spanish Engineers is made by mixing in several proportions fat limes with sand and under-burnt brick dust. The usual proportions are measured by equal volumes of the three materials; but when the cement is to be used for stopping roof leaks, cementing cellars, or where blows upon the cement are not anticipated, the proportion of sand is greatly diminished, and even suppressed altogether.

The Spanish learned the compounding of this cement from the Biscayans probably; and I doubt if the Romans had anything to do with its introduction in Spain, because the ruins of ancient water channels with "revocado" exist in the Basque provinces, where neither Romans nor Moors ever penetrated. The Biscayans, in their turn, are the most ancient people with whom we are acquainted, it being probable that they preceded the Phœnicians.

I have seen Spanish "revocado" in Mexico, and it is natural to suppose that the Spaniards introduced the art in that country during the Conquest.

Now, may it not be possible that the ochre referred to by Gen. Ellis is only powdered brick, used to make the excellent and hard "revocado?"

The description given of the method of consolidating the mortar, etc., and even the employment of wooden compressors, explain accurately the process still followed in Spanish countries to form the floorings of plazas, public walks, etc.

In many cases, immediately before the cement becomes set, its surface is polished with a smooth cobble stone until it acquires a high and lasting lustre.

From Gen. Ellis, in reply to the above:

Having read the remarks of Mr. Fuertes upon my recent paper relating to hard lime floors, I apprehend that he did not give sufficient attention to the process therein described.

In no case was the red pigment mixed with the lime and sand, as he supposes, but was solely used for a surface coloring after the hardening process was completed. Roofs and sidewalks of equal hardness were also made by the same process of successive poundings without the coloring matter, and finished by polishing in the same manner as the colored floors.

The pigment used upon the floors was not brick dust, but a red earth found in the vicinity, probably a fine clay colored with sesquioxide of iron. Bricks were not used in that part of the country; "adobes" taking their place in building.

It will thus be seen that the material of which the described floors and roofs were made was not the same as the "revocado" used in Spain and Southern Mexico, described by Mr. Fuertes. Is not the term *revocado* essentially the same in meaning as the more common Castilian word *revoque*, one being the participle and the other the noun corresponding to the Spanish verb *revocar*, the nearest English equivalent to which, in an engineering sense, is to *rough cast*. This implies an admixture of coarse material in the mortar. "Revoque" was known to the Romans as "*parietis linimentum*."

Mr. Fuertes, is, I think, in error when he attributes any rapidity of setting, greater hardness when set, or improved hydraulic qualities, to the mixture of burnt or underburnt brick in any proportions with lime. The experiments of Smeaton show conclusively that the only gain is the slight amount of moisture that the brick will absorb from the lime and favor its *drying*.

The only way in which hydraulic properties can be given to a compound of silicate of alumina and carbonate of lime is by burning them together after being mixed, as in the production of artificial cement. This is exactly what was done in the case Mr. Fuertes recounts; clay and chalk were burned together, and if in proper proportions would form an excellent artificial cement. It is not remarkable that neither should be a good building material by itself.

If the "revocado" of the Spanish possesses any quick setting or hydraulic qualities, it is probably not owing to the admixture of common brick, but to some qualities of the lime, or perhaps what Mr. Fuertes has taken to be brick was artificial "trass," formerly much used, which was burned like brick, and when added to mortar, gave it hydraulic properties.

I think it highly probable that the process of pounding ordinary lime mortar for many successive days in order to give it hardness, and afterwards polishing the surface, originally came from Spain to Mexico, and is probably an ancient practice. The only matter of surprise is that it has not become more generally known and used.

Note by the Printing Committee.

Is this "pounding process" of the Mexicans anything more than a simple yet effectual method of freeing the mortar of its *surplus water*, and thereby insuring a condition in which the lime can pass to a crystalline carbonate, at the same time compacting the whole mass into the best possible state?—*Vide* "Transactions" of this Society, No. X.

A Chemical Experiment.—A very pretty experiment, the uses for which may be judged by our readers, can be arranged as follows: Dissolve about 500 grains of nitrate of lead in six fluid-ounces of water, permit the same to stand until any turbidity may have subsided, and decant off the clear supernatant liquid, or, if convenient, filter the solution. Place the last in the position where it is intended it shall remain, and drop into it a few long, fibrous particles of sal ammoniac. Small crystals of chloride of lead begin to form, and ascend through the liquid, presenting the appearance of an ascending snow storm. When the lead is all precipitated the crystals of chloride begin to descend, forming, in their descent, grotesque masses resembling a winter landscape. If the vessel containing the reagents is not disturbed, it often presents its beauty for a week or two.

Chemistry, Physics, Technology, etc.

COMBUSTION IN COMPRESSED AIR.

By F. Collingwood, C. E.

Read before the Lyceum of Natural History, New York, Feb. 10, 1873.

In bringing up this subject at the present time, I do not know that I can offer any positive results; it is done rather with the hope that the discussion which may ensue may help to harmonize those which appear to be conflicting.

The observations made in the St. Louis caisson were at first reported as showing a decided increase in energy and amount of combustion as the air-pressure was increased. Quite recently, however, in the Franklin Institute "Journal," the statement is made that this was a mistake, and that there was *no* increase.

In the caissons of the East River bridge there was an admirable opportunity to test the question; but the engineers considered the fact that there *was* practically an increase to be a settled one, and the only facts they have, therefore, bearing upon the question were incidentally obtained while experimenting in another direction.

The fact of *imperfect* combustion of candles and other hydro-carbons when in compressed air was universally acknowledged, and the great annoyance from the smoke caused thereby, very early in the progress of the work, led to experiments with a view of removing, or at least alleviating the nuisance.

The first experiments were made with great care by Col. W. H. Paine. He tried various oils, common candles, and the *adamantine* candles, so called, of the size known as coach candles. The latter are composed of stearin, and are quite uniform in manufacture. They are 1¼ inch in diameter, and weigh three to the pound.

No *measurement* was made of the oils consumed; but at only eight pounds pressure above the atmosphere he noticed a very decided increase in the amount.

Of the two kinds of candles the results compared very closely, but as he recorded only the figures taken in connection with the coach candles, these remarks are necessarily restricted to them.

The elements noted were pressures of the air in the caisson (that above being taken at 15 lbs.), temperatures and quantities. In determining quantities, the lengths burned in a given time were noted, and the average of a number of experiments was taken. From these the

time required to burn a pound was deduced, and from this in turn the relative consumption as compared with that in open air of the same temperature.

The results obtained, when tabulated, are as follows:

No. of Experiment.	Absolute Pressure.	Time of burning 1 lb. of candles.	Relative Consumption.	Temperature.	Square root of Pressure.	Ratios of square roots of Pressure.
1	Open air = 15 lbs.	32 hours	1·	80°	3·873	1·
2	23	27	1·185+	80°	4·796	1·239
3	25	25½	1·255—	80°	5·000	1·291
4	Open air = 15	28	1·	88°	3·873	1·
5	46	16	1·75	88°	6·782	1·751

Candles carried about, at the time of experiment No. 2 (the pressure being 8 pounds above the atmosphere) would burn at the rate of a pound in 18 hours, and in a still less time when the pressure was increased. This shows a waste of one-third from flaring of the flame when in motion.

The effect of increased temperature in the open air is shown by experiments 1 and 4, although these were made with different lots of candles.

Comparing experiments 4 and 5 shows an increase in consumption of 75 per cent. by increasing the pressure of the air to three atmospheres.

Comparing 1 and 3 shows an increase of about 18 per cent. in consumption for 50 per cent. increase of pressure.

Unfortunately, the series of experiments is too incomplete to allow the establishment of a law of increase; but I found by trial that the ratio given in the 4th column compared quite closely with that given in the 7th. In other words, the amount of consumption at various pressures is *approximately*, at least, as the square roots of those pressures.

Independent of theoretical considerations, this result is of value as a practical fact, which gives a ready rule for determining the amount of supplies needed in any similar case. It would have been of great value to us as a check upon "stealage" and waste, had we known it in advance.

Whether more refined experiments may prove the opposite of these results to be true, such facts as those which follow were certainly matters of common observation, viz., the instant relighting of a candle when blown out, for a *number* of times in succession (in the St. Louis caisson it was done 20 times); the quick ignition of even a woolen

garment, if brought momentarily in contact with a flame; a cigar bursting into a flame in ordinary smoking (although, as the engineers were not smokers, they have this from hearsay only).

The question will next be asked, what precautions were taken against error in these observations?

1st. Differences of temperature, above and below, were carefully guarded against.

2d. Air-currents were entirely prevented, the tests being made in the centre of a chamber, 100 × 26 feet, in which at the time no work was progressing, and the air supply was at least 20 feet away.

3d. Impurity of the air was impossible. The total air space in the chamber was at least 130,000 cubic feet, and the air was entirely changed at least once every 1½ hour, and often in less time.

4th. Lack of homogeneity of materials. This was guarded against as far as possible by always taking candles from the same boxes.

5th. Possible effects of excess of moisture in the air of caissons. This could not be prevented. The process of condensation develops so much heat, that a spray of water has to be thrown into each air compressor constantly, to prevent heating of the machinery.

6th. It is submitted as a suggestion, whether a test by "standard" candles, owing to the fineness of the wick, might not lead to error, from the fact that the *capacity* of the *wick* is not increased by pressure. The only experiments made with these were by Prof. Seely, who reports but about 5 per cent. increase of consumption at 46 lbs. pressure, and attributes the discrepancy to this cause.

An experiment made with alcohol at the same pressure and 88° temperature, tends to confirm this view. The lamp had a loose cotton wick, ¼″ in diameter, and burned in the caisson *six* cubic inches per hour, and in the open air *two* cubic inches. Here we have, then, standard candles increasing 5 per ct. only; stearine candles, with wicks not so nicely adjusted, increasing 75 per cent.; and *alcohol*, the most limpid of all and most readily carried by capillary attraction, increasing 200 per cent. It will be noted that in the latter case the consumption was almost directly proportional to the pressures.

Another difference noted in the case of alcohol was that the flame in the caisson was entirely changed in appearance; being no longer blue, but of a white color, giving about three-fourths as much light as a coach candle.

Unfortunately, on comparing the cost of candles and alcohol, making full allowance for waste, the latter was found to be at least twice as great as the former. It is quite probable that a slight carboniz in

of the flame would have increased the light, thus diminishing cost without causing smoke, the amount of carbonizing being graduated to suit the pressure.

A serious objection might arise, however, from the possible danger of using so inflammable a substance in a confined space.

As a final resort for light in both caissons the street gas was introduced, and, to guard against accident from explosion, it was made one man's constant duty on every watch to attend to its lighting, regulating, turning off, &c. This did admirable service in the Brooklyn caisson, where the pressures were light; but in the New York caisson, after reaching about 20 pounds pressure above the atmosphere, the gas-lights began to smoke fearfully.

Following up the idea, that the cause of the smoke was a lack of *ventilation* of the flame—in other words, of circulation of the air around it—it occurred to me that if the gas could be spread more, or thrown out in a thinner sheet, the light would be improved. For this purpose the *size* of the burners was reduced from a six-foot fish-tail to a two-foot bat-wing, of the kind known as the "excavated tip." The result was entire freedom (for the time) from smoke, less gas burned, and a better light. At about 28 pounds pressure above atmosphere these smoked badly, and were exchanged for one-foot burners of the same pattern. The latter answered a good purpose up to the close of the work.

In this experience there arises an incidental proof of the fact that the energy of combustion was increased, which is this:

The excess of pressure at the burners under which the gas was consumed was fully two inches of water, and I am informed that it would be *impossible* to get *any* light from a burner in the open air under such pressure, one-half inch being the best pressure in most cases. An argand burner gives the best light at only fifteen-hundredths of an inch pressure. At any less than two inches in the caisson, however, the light was poor, and at half an inch the lights would go out.

This measurement was made near the centre of the caisson, but I am satisfied that many of the lights burned at still *higher* pressures.

This completes the record and discussion of experiments; and it remains only to be shown that when a flame is exposed to pressure its relations to the surrounding air are essentially changed, and that we might reasonably expect a change in the energy of combustion.

Turn a moment, if you please, to the fundamental relations of magnitude, viz., *volume, surface, linear dimensions*. *Volumes*, in bodies

of similar form, are said to vary as the *cubes* of similar lines, and *surfaces* of the same bodies as the *squares* of the same lines.

Suppose, then, we have volumes (flames, if you please) having diameters 1, 2, 3, 4. Their surfaces will be as 1, 4, 9, 16, and their *volumes* as 1, 8, 27, 64.

Manifestly, then, if we diminish a volume, we by no means diminish the corresponding surface in the same ratio. A volume one-half the size of 64 would be 32, but its *surface* would be considerably more than half of 16; and in order to obtain it, we must multiply 16 by the square of the cube root of $\frac{1}{2}$.

Turn next to the consideration of flame itself. In ordinary combustion for purposes of illumination a hydro-carbon in the form of liquid is carried up along a wick by capillary attraction. Meeting the point where combustion is progressing it is distilled. The gases and vapors evolved have a tension exactly equal to that of the surrounding air. If the temperature of the flame be increased, with *no* increase of combustion, the flame would tend to expand in size. If the pressure of the air be *diminished* the flame would tend to expand also. On the contrary, if temperature be diminished and pressure increased the flame would *diminish* in size.

Again: if the flame be diminished in size by condensation, supposing *no* increase in combustion, the temperature will necessarily increase, from the simple fact of condensation. In every case, therefore, there will be somewhere a balance between these opposing tendencies.

But we have not yet decided the cause of the flame assuming primarily any specific volume. This manifestly will be reached when the flame has expanded sufficiently to allow the chemical combination of its distilled gases with the oxygen of the air to progress at its surface as rapidly as these gases are distilled by the heat of the flame.

Now, to apply these principles, let us prepare a table as follows, using the pressures noted in the previous table:

Absolute pressures.	Volumes of gases by Marriotte's law.	Surfaces. Deduced by taking $\frac{2}{3}$ power of the volumes.	Ratios of surfaces to corresponding volumes.
15	$\frac{15}{15} = 1$	1·	1·
23	$\frac{15}{23} = 0{\cdot}652$	0·752	1·153
25	$\frac{15}{25} = 0{\cdot}6$	0·711	1·185
46	$\frac{15}{46} = 0{\cdot}326$	0·474	1·453

The law that under a constant temperature the volumes of gases vary inversely as their pressures, gives at once the second column from the first, for the volume of the same quantity of gas under the different pressures named.

If these various volumes have similar forms, as in the case of a flame, then manifestly they will have *surfaces* as in the third column.

Taking next the ratio of each surface to its corresponding volume, we get the fourth column, and we have arrived at this result:

That the surface of a flame, in proportion to its volume, will be nearly half greater under three atmospheres of pressure than under one; this being under the condition of an invariable temperature, and supposing that no other considerations modify the result.

Admitting these suppositions, and remembering that every part of this additional surface is three times as rich in oxygen, it is at once evident that the facility for the chemical forces to act is increased; and we would expect increased energy of combustion, increased temperature, and *consequently* an increase of distillation and consumption of material.

Some of the modifying considerations are as follows:

Loss of heat by radiation and convection, nitrogen also being present in increased proportion.

The varying rapidity with which the various substances—wax, alcohol, &c.—will be carried by a wick.

A technical point may be made, also, as to whether carbon passing off as lampblack can be said to be consumed. As to this, it is sufficient to say that it *is* consumed, from the practical point of view, at least it has to be paid for.

It is with much hesitation that the views expressed in this paper have been advanced, more especially as the author has not the leisure necessary to give them careful thought, or to make farther experiments.

They may be proven to be entirely erroneous, but he trusts they may help in some degree to a clearer knowledge of the subject discussed.

ON SYMPATHETIC VIBRATIONS, AS EXHIBITED IN ORDINARY MACHINERY.

By Joseph Lovering, of Cambridge, Mass.

At the meeting of this Association in Burlington, I showed some experiments in illustration of the *optical method* of making sensible the vibrations of the column of air in an organ-pipe. At the Chicago meeting, I demonstrated the way in which the vibrations of strings could be studied by the eye in place of the ear, when these strings were attached to tuning-forks with which they could vibrate in sympathy; substituting for the small forks, originally used by Melde, a colossal tuning fork, the prongs of which were placed between the poles of a powerful electro-magnet. This fork, which interrupted the battery current, at the proper time, by its own motion, was able to put a heavy cord, thirty feet in length, in the most energetic vibration, and for an indefinite time. I propose, at the present time, to speak of those sympathetic vibrations which are pitched so low as not to come within the limits of human ears, but which are felt rather than heard, and to show how they may be seen as well as felt.

All structures, large or small, simple or complex, have a definite rate of vibration, depending on their materials, size and shape, and as fixed as the fundamental note of a musical cord. They may also vibrate *in parts*, as the cord does, and thus be capable of various increasing rates of vibration, which constitute their harmonics. If one body vibrates, all others in the neighborhood will respond, if the rate of vibration in the first agrees with their own principal or secondary rates of vibration, even when no more substantial bond than the air unites a body with its neighbors. In this way, mechanical disturbances, harmless in their origin, assume a troublesome and perhaps a dangerous character, when they enter bodies all too ready to move at the required rate, and sometimes beyond the sphere of their stability.

When the bridge at Colebrooke Dale (the first iron bridge in the world) was building, a fiddler came along and said to the workmen that he could fiddle their bridge down. The builders thought this boast a fiddle-de-dee, and invited the itinerant musician to fiddle away to his heart's content. One note after another was struck upon the strings until one was found with which the bridge was in sympathy. When the bridge began to shake violently, the incredulous workmen were alarmed at the unexpected result, and ordered the fiddler to stop.

At one time, considerable annoyance was experienced in one of the mills in Lowell, because the walls of the building and the floors were violently shaken by the machinery; so much so that, on certain days, a pail of water would be nearly emptied of its contents, while on other days all was quiet. Upon investigation it appeared that the building shook in response to the motion of the machinery only when that moved at a particular rate, coinciding with one of the harmonics of the structure; and the simple remedy for the trouble consisted in making the machinery move at a little more or a little less speed, so as to put it out of time with the building.

We can easily believe that, in many cases, these violent vibrations will loosen the cement and derange the parts of a building, so that it may afterwards fall under the pressure of a weight which otherwise it was fully able to bear, and at a time, possibly, when the machinery is not in motion; and this may have something to do with such accidents as that which happened to the Pemberton mills in Lawrence. Large trees are uprooted in powerful gales, because the wind comes in gusts; and if these gusts happen to be timed in accordance with the natural swing of the tree, the effect is irresistible. The slow vibrations which proceed from the largest pipes of a large organ, and which are below the range of musical sounds, are able to shake the walls and floors of a building so as to be felt, if not heard, thereby furnishing a background of noise on which the true musical sounds may be projected.

We have here the reason of the rule observed by marching armies when they cross a bridge, viz., to stop the music, break step and open column, lest the measured cadence of a condensed mass of men should urge the bridge to vibrate beyond its sphere of cohesion. A neglect of this rule has led to serious accidents. The Broughton bridge, near Manchester, gave way beneath the measured tread of only sixty men who were marching over it. The celebrated engineer, Robert Stephenson, has remarked* that there is not so much danger to a bridge, when it is crowded with men or cattle, or if cavalry are passing over it, as when men go over it in marching order. A chain-bridge crosses the river Dordogne on the road to Bordeaux. One of the Stephensons passed over it in 1845, and was so much struck with its defects, although it had been recently erected, that he notified the authorities in regard to them, A few years afterwards it gave way when troops were marching over it.†

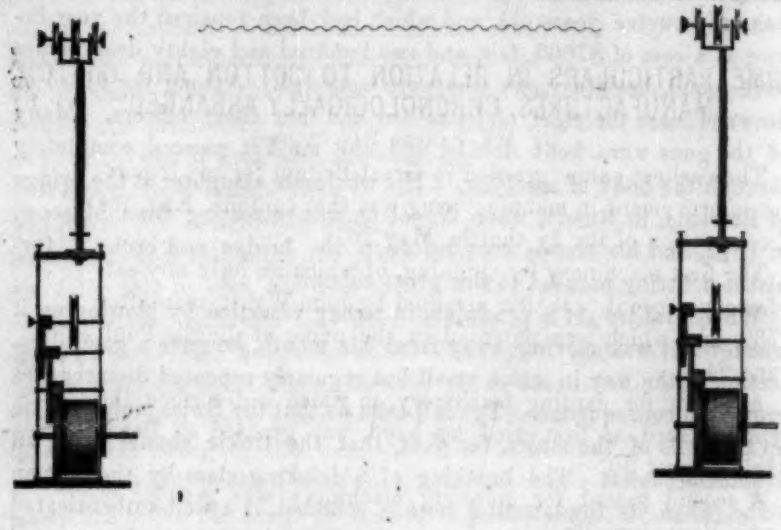
* Edin. Phil. Journ., v, p. 255. † Smith's Life of Stephenson, p. 390.

A few years ago, a terrible disaster befel a battalion of French infantry while crossing the suspension bridge at Angiers, in France. Reiterated warnings were given to the troops to break into sections, as is usually done. But the rain was falling heavily, and, in the hurry of the moment, the orders were disregarded. The bridge, which was only twelve years old, and which had been repaired the year before at a cost of $7000, fell, and two hundred and eighty dead bodies were found, besides many who were wounded. Among the killed or drowned were the chief of battallion and four other officers. Many of the guns were bent double, and one musket pierced completely through the body of a soldier. The wholesale slaughter at the bridge of Beresina, in Russia, when Napoleon was retreating from Moscow, in 1812, and his troops crowded upon the bridge and broke it, furnishes a fitting parallel to this great calamity.

When Galileo set a pendulum in strong vibration by blowing on it whenever it was moving away from his mouth, he gave a good illustration of the way in which small but regularly repeated disturbances grow into consequence. Tyndall tells us that the Swiss muleteers tie up the bells of the mules, for fear that the tinkle should bring an avalanche down. The breaking of a drinking-glass by the human voice, when its fundamental note is sounded, is a well-authenticated feat; and Chladni mentions an innkeeper who frequently repeated the experiment for the entertainment of his guests and his own profit. The nightingale is said to kill by the power of its notes. The bark of a dog is able to call forth a response from certain strings of the piano. And a curious passage has been pointed out in the Talmud, which discusses the indemnity to be claimed when a vessel is broken by the voice of a domestic animal. If we enter the domain of music, there is no end to the illustrations which might be given of these sympathetic vibrations. They play a conspicuous part in most musical instruments, and the sounds which these instruments produce would be meagre and ineffective without them.

In the case of vibrations which are simply mechanical, without being audible, or at any rate musical, the following ocular demonstration may be given. A train of wheels, set in motion by a strong spring wound up in a drum, causes a horizontal spindle to revolve with great velocity. Two pieces of apparatus like this are placed at the opposite sides of a room. On the ends of the spindles which face one another are attached buttons about an inch in diameter. The two ends of a piece of white tape are fastened to the rims of these buttons.

When the spindles, with the attached buttons, revolve, the two ends of the tape revolve, and in such directions as to prevent the tape from twisting, unless the velocities are different. Even if the two trains of wheels move with unequal velocities, when independent of each



other, the motions tend to uniformity when the two spindles are connected by the tape. Now, by moving slightly the apparatus at one end of the room, the tape may be tightened or loosened. If the tape is tightened, its rate of vibration is increased, and, at the same time, the velocity of the spindles is diminished on account of the greater resistance. If the tape is slackened, its rate of vibration is less, and the velocity of the spindles is greater. By this change we can readily bring the fundamental vibration of the tape into unison with the machinery, and then the tape responds by a vibration of great amplitude, visible to all beholders. If we begin gradually to loosen the tape, it soon ceases to respond, on account of the twofold effect already described, until the time comes when the velocity of the machinery accords with the first harmonic of the tape, and the latter divides beautifully into two vibrating segments with a node at the middle. As the tension slowly diminishes, the different harmonics are successively developed, until finally the tape is broken up into numerous segments only an inch or two in length. The eye is as much delighted by this visible music as the ear could be if the vibrations were audible; and the optical demonstration has this advantage,

that all may see, while few have musical ears. A tape is preferred to a cord in this experiment, because it is better seen, and any accidental twist it may acquire is less troublesome. The wood-cuts on the opposite page represent the apparatus used, drawn on a scale of one inch to five inches.

SOME PARTICULARS IN RELATION TO COTTON AND COTTON MANUFACTURES, CHRONOLOGICALLY ARRANGED.*

By Mr. Samuel Batchelder.

The earliest patent granted in Great Britain for any important improvement in manufacturing was that to John Kay, for the invention of the fly shuttle, May 26, ... 1733

The first machinery for spinning, of which we have any satisfactory account, was that invented by John Wyatt, soon after 1730, and which was patented in the name of Lewis Paul, June 24, ... 1738

A patent for carding machinery, in which is described the cylinder card, as first used by hand, was granted to Lewis Paul, August 30, ... 1748

A second patent for spinning machinery was granted to Lewis Paul, June 29, ... 1758

The invention of the drop-box by Robert Kay, by means of which filling of different colors could be used with the fly-shuttle, ... 1760

According to Guest, the spinning-jenny was invented by Thomas Highs, ... 1764

The invention is also claimed by James Hargraves, who took a patent for it, June 12, ... 1770

Arkwright's first patent for spinning machinery, July 8, . 1769

Act of Parliament to prohibit the exportation of machinery, 1774

Second patent to Arkwright, including Carding, Drawing and Spinning, was granted December 16, ... 1775

Patent to Robert Peele, for Carding, Roving and Spinning, February 18, ... 1779

Mule spinning invented by Samuel Crompton (not patented) 1779

James Watt took his first patents for improvements in steam engine, March 12, ... 1782

Subsequent patents in 1784 and 1785.

* From the Bulletin of the National Association of Wool Manufacturers.

Power-loom invented by Edmund Cartwright, first patent, April 4, ... 1785

Subsequent patents, 1786, 1787, 1788.

Arkwright's patents declared void, ... 1785

Cylinder printing was patented by Thomas Bell, July 17, 1783, and introduced in Lancashire, ... 1785

Bleaching by oxymuriatic acid was discovered in France by Berthollet, ... 1785

And introduced at Manchester practically 1788

Legislature of Massachusetts made a grant to Robert and Alexander Barr to aid them in building machinery for spinning cotton, ... 1786

First machinery for spinning cotton put in operation in France, ... 1787

Grant to Thomas Somers by the Legislature of Massachusetts, to aid him in completing machines for spinning, . . 1787

First cotton factory built in the United States at Beverly, Massachusetts, ... 1787

Some spinning-jennies were put in operation in Philadelphia and Providence, ... 1788

Commencement of the cultivation of Sea Island cotton in Georgia, from Pernambuco seed, ... 1789

Samuel Slater came to this country, and was employed at New York, where he said they had in operation one carding engine and two spinning-jennies, at the close of the year, . 1789

Slater came to Providence, Rhode Island, and began building a cotton factory, ... 1790

In which they commenced spinning early in 1791

Cotton gin invented by Eli Whitney in 1793, and patented March 14, ... 1794

Cotton mill built by Slater and others at Pawtucket, Massachusetts, ... 1798

First cotton mill and machinery in Switzerland, . . 1798

First spinning machinery in Saxony, ... 1799

Water-mill at Beverly, Massachusetts, with Arkwright machinery, ... 1802

First cotton mill in New Hampshire commenced at New Ipswich in 1803, and went into operation 1804

Second mill at Pawtucket, Massachusetts, ... 1805

Mill at Pomfret, Connecticut, ... 1806

After the patents for a power-loom to Edmund Cartwright, several other patents were taken by other parties, some of which went into partial operation, but none with any success, until the invention of the dressing-frame by Radcliff and Ross, with the assistance of Thomas Johnson. Guest gives the date of this invention 1803, Baines in 1804. One of the patents to Thomas Johnson was issued Feb. 28, 1803, and another June 2, 1804; and a mill for weaving was built at Manchester in 1806, which may be considered the date of the successful commencement of power-loom weaving, . . 1806

Mill built at Smithfield, Rhode Island, by John Slater, . 1807

Mill built at Watertown, Massachusetts, ... 1807

Second cotton mill in New Hampihire at New Ipswich, . 1808

Norfolk cotton factory at Dedham, incorporated, . . 1808

First cotton mill in Maine, at Brunswick, . . . 1809

Mill at Dorchester, Massachusetts, incorporated, . . 1811

Incorporation of Boston Manufacturing Company, known as *Waltham Company*, ... 1813

Power-looms in operation at Waltham, being the first in the United States, ... 1814

William Gilmore emigrated to this country, . . . 1815

And put the crank-loom in operation in Rhode Island, . . 1817

First cotton factory built at Lowell, ... 1822

Self-acting mule patented by Richard Roberts, March 29, . 1825

First cotton mill at Lawrence, Massachusetts, . . . 1849

There is so much uncertainty and inaccuracy as to the dates of many improvements and inventions in cotton machinery in the accounts given by Guest, Kennedy, Baines and others, who seem to have copied one another's errors, instead of correcting them, that I have referred for the dates of all patented improvements to the collection of "Specifications of Inventions from March 2, 1617, to October 1, 1852," in Great Britain, contained one hundred and sixty volumes of text, and three hundred and ten volumes of plates, a copy of which may be found in the Boston Library.

SOME PARTICULARS IN RELATION TO WOOL AND WOOLEN MANUFACTURES, CHRONOLOGICALLY ARRANGED.*

By Editor of Bulletin of N. A. W. M.

The export of wool from England, first prohibited in the reign of Edward III, ... 1337

The stocking-frame, invented by William Lea, . . . 1585

Sheep introduced at Jamestown, Virginia, ... 1609

And first brought to Boston in 1633

The first fulling-mill erected at Rowley, Massachusetts, by "Mr. Roger's people, who were the first that set upon making cloth in this Western world," 1643

Exportation of wool from England definitely prohibited, . 1660

Which prohibition continued until 1825

The fly-shuttle first used by woolen weavers, and used very little by weavers of cotton until 1760, invented by John Kay, 1733

The first ram let by Mr. Bakewell, the improver of the English Leicester sheep, in 1760

Spanish merino sheep introduced into Saxony by the Elector, ... 1765

Merinos introduced into Hungary by Maria Theresa, . 1775

Merinos imported from Spain to France, ... 1776

A French manufacturer announced that he had carded wool with success on a cotton carding-machine in 1783

The first machine for spinning wool was tried at Dolphin Holme, England, ... 1784

Merinos introduced at Rambouillet, France, by Daubenton, in 1786

The first woolen factory established and conducted advantageously in America, erected in that portion of Newbury, Massachusetts, known as Byfield Parish, ... 1714

The first carding-machine for wool put in operation in the United States, constructed under the supervision of John and Arthur Schofield, ... 1794

Carding-machine erected by Arthur Schofield, at Pittsfield, Massachusetts, ... 1800

The fabric called French merino, introduced by Dauphinot Pallotan, at Rheims, France, ... 1801

The first merinos known to have left full-blood descendants,

* From the Bulletin of the National Association of Wool Manufacturers.

introduced to United States by Col. Humphreys, the American minister to Spain, on his return from his embassy, in . 1802

Gray mixed broadcloth made at Pittsfield, and sold in New York as foreign, ... 1804

Importations by Wm. Jarvis of nearly 4,000 merinos, 1809 to 1810

The first bale of wool came to England from Australia in . 1810

Card clothing machine invented by Elijah Smith, of Walpole Mass., and patented by Whittemore, ... 1810

The loom for weaving figured fabrics called Jaquard, invented by Joseph Maria Jaquard in 1811

Machine for shearing cloth, called a machine with helicoidal shears, introduced into France by George Bass, of Boston, in 1812

The largest manufactory of fine cloths in New England, the Middletown Manuf. Co., made daily 30 to 40 yards of broadcloth, which sold by the piece at $9 to $10 per yard, in . 1812

Shoddy first introduced at Batley, England, about . . 1813

The Pittsfield Wool Manufacturing Company, Lemuel Pomeroy & Co., incorporated, ... 1814

The Glenham Wool Manufacturing Company Mill erected in Dutchess County, New York 1814

The principle of helicoidal shears, introduced by Bass, adopted by Collier, of Paris, in 1817

Saxony merinos introduced into United States under impulse of wool tariff, maintaining an almost undisputed ascendancy for about fifteen years, ... 1824

Mousselines de laine made a fine wool for printing, introduced at Troixville, France, ... 1826

The invention of William Goulding, dispensing with the billy and obtaining the endless roll, patented 1826

The knitting-frame first operated by power at Cohoes, New York, by Egbert Egberts, ... 1832

Mousseline de laine with cotton warps introduced in France, 1833

Fancy cassimeres invented by Bonjean at Sedan, France, . 1834

Machine for burring wool invented, and first successfully used by Michael H. Simpson, of Boston, Mass., . . . 1834

The manufacture of shoddy from felted cloths, first undertaken on a grand scale at Batley, Yorkshire, . . . 1840

Automatic weaving of ingrain carpets invented by E. B. Bigelow, of Boston, ... 1842

The mechanical comber for drawing out the fibre at both